Red Snapper (*Lutjanus campechanus*) larval indices of relative abundance from SEAMAP fall plankton surveys, 1986 to 2010

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Abstract: *The occurrence and abundance of red snapper larvae captured during Southeast Area Monitoring and Assessment Program (SEAMAP) resource surveys in the Gulf of Mexico (GOM) have been used to reflect trends in relative spawning stock size of red snapper since 2004. The larval indices presented in this document are based on data from SEAMAP Fall Plankton surveys which began in 1986. New work with daily aging larval red snapper has led to the possibility to back calculate to the number of seven day old larvae. Six abundance indices are presented in this document: Eastern Gulf of Mexico (EGOM), Western Gulf of Mexico (WGOM), entire Gulf of Mexico (GOM), Eastern Gulf of Mexico with catch adjusted to 10.5 day old larvae (EGOM-adjusted), Western Gulf of Mexico with catch adjusted to 10.5 day old larvae (WGOM-adjusted) and entire Gulf of Mexico with catch adjusted to 10.5 day old larvae (GOM-adjusted).*

Introduction

The Southeast Area Monitoring and Assessment Program (SEAMAP) has supported collection and analysis of ichthyoplankton samples from resource surveys in the Gulf of Mexico (GOM) since 1982 with the goal of producing a long-term database on the early life stages of fishes. These surveys are the only Gulf-wide survey of U.S. continental shelf and coastal waters during the red snapper spawning season. The occurrence and abundance of red snapper (*Lutjanus campechanus*) larvae captured during SEAMAP resource surveys in the Gulf of Mexico have been used to reflect trends in relative spawning stock size of red snapper since 2004. In the 2004 assessment, the SEAMAP larval index was calculated from catches in bongo net samples taken during the Fall Plankton Survey.

The SEAMAP Fall Plankton survey was selected because of its spatial coverage, as opposed to surveys in the summer which do not adequately cover the eastern GOM. However, spatial coverage in the eastern gulf has improved recently during the summer groundfish survey since the expansion of the sampling universe and in the future could be utilized for larval abundance indices. Therefore, the larval indices presented in this document are based solely on data from SEAMAP Fall Plankton surveys from 1986-2010. In addition, age-corrected indices are presented for the first time using larval length-at-age data. Data from 2011 was not included because all the quality checks on the data have not yet been completed. The purpose of this document is to provide abundance indices for larval red snapper.

Methodology

SEAMAP Plankton Sample Methodologies

The standard sampling gear and methodology used to collect plankton samples during SEAMAP surveys were similar to those recommended by Kramer et al. (1972), Smith and Richardson

(1977) and Posgay and Marak (1980). A 61 cm (outside diameter) bongo net fitted with 0.335 mm mesh netting was fished in an oblique tow path from a maximum depth of 200 m or to 2-5 m off the bottom at station depths less than 200 m. Maximum bongo tow depth was calculated using the amount of wire paid out and the wire angle at the 'targeted' maximum tow depth or measured directly using an electronic depth sensor mounted on the tow cable. A mechanical flowmeter was mounted off-center in the mouth of each bongo net to record the volume of water filtered. Water volume filtered during bongo net tows ranged from ~20 to 600 m^3 but was typically 30 to 40 m^3 at the shallowest stations and 300 to 400 m^3 at the deepest stations.

Catches of larvae in bongo net samples were standardized to account for sampling effort and expressed as number under 10 m^2 sea surface by dividing the number of larvae by volume filtered and then multiplying the resultant by the product of 10 and maximum depth of tow. This procedure resulted in a less biased estimate of abundance than number per unit of volume filtered alone and permitted direct comparison of abundance estimates across samples taken over a wide range of water column depths (Smith and Richardson 1977).

Sample Processing and Identification of Snapper Larvae

Initial processing of most SEAMAP plankton samples has been carried out at the Sea Fisheries Institute, Plankton Sorting and Identification Center (ZSIOP), in Szczecin, Poland, under a Joint Studies Agreement with NMFS. Fish eggs and larvae were removed from bongo net samples. Fish eggs were not identified further, whereas, larvae were identified to the lowest possible taxon which in most cases was the family level. Body length (BL) in mm was measured and recorded.

In order to assure consistent identifications over the SEAMAP time series, all snapper larvae were examined and identified by ichthyoplankton specialists at the SEFSC Mississippi Laboratories using an identification protocol based on descriptions in Drass et al. (2000) and Lindeman et al. (2005). The level of identification achievable under this protocol depended on the extent of first dorsal fin development, as well as the following morphological traits: presence or absence of melanistic pigment on the throat (sternohyoideus muscle), and on the anterior surface of the visceral mass or gut; and whether preopercular spines or dorsal spines were smooth or serrated. Specimens were identified as red snapper only when a minimum of five dorsal spines were present, those spines were smooth, not serrated and melanistic pigmentation on the body and fins matched the description and illustrations of reared and wild caught red snapper larvae in Rabalais *et al.* (1980), Collins *et al.* (1980), and Drass *et al.* (2000).

Red snapper are among six of the twelve snapper species of the subfamily Lutjaninae found in the GOM whose larvae have been described. Despite these descriptions snapper larvae can be distinguished from each other only after dorsal and pelvic spines have begun to develop using a combination of morphological characters (Lindeman et al. 2005). Red snapper larvae prior to dorsal and pelvic spine formation are generally less than 3.5 mm BL and cannot be confidently identified in field collections because of the lack of established characteristics that permit early stage larvae of the lutjanines to be distinguished from each other. The few specimens identifiable as red snapper in SEAMAP collections that were less than 3.5 mm BL resulted from variability in size at developmental stage and/or shrinkage during capture and preservation. The question arises as to the potential for misidentification of red snapper larvae in SEAMAP collections since the larvae of all snappers found in the region have not been described. It is unlikely that this caused extensive misidentification of red snapper larvae considering how much the larvae of species whose larval development has been described differ from each other and red snapper in pigmentation and body shape (Drass *et al.* 2000). Most of the snappers whose larvae remain undescribed inhabit coral reefs and reef associated ledges as adults, and clear shallow waters or mangrove areas as juveniles (Anderson 2003); biotopes of limited extent in the northern GOM (Parker *et al.* 1983). No adults or juveniles of the six snapper species whose larvae are undescribed were taken during annual summer and fall SEAMAP shrimp/bottomfish (trawl) surveys from 1982 to 2005 (G. Pellegrin, NOAA/SEFSC Mississippi Laboratories, personal communication). Fewer than five individuals per year of these species were ever observed during ten years of NMFS reef fish video surveys of reef and hard bottom habitat from Brownsville, Texas to the Florida Keys (K. Rademacher, NMFS/SEFSC Mississippi Laboratories, personal communication).

Standardized SEAMAP Station/Sample Data Set

The overall SEAMAP plankton sampling area covers the northern GOM from the 10 m isobath out to the U.S. EEZ, and comprises approximately 300 designated sampling sites i.e. 'SEAMAP' stations. Most stations are located at 30-nautical mile or 0.5^{o} (~56 km) intervals in a fixed, systematic, 2-dimensional (latitude-longitude) grid of transects across the GOM. Some SEAMAP stations are located at < 56 km intervals especially along the continental shelf edge, while others have been moved to avoid obstructions, navigational hazards or shallow water.

Plankton sampling was conducted during the SEAMAP Fall Plankton survey (late summer/early fall (typically in September, annually, 1986 to present)). The area surveyed during Fall Plankton cruises was consistently sampled for 22 of the 25 years since the survey began in 1986. The three 'missing' fall plankton survey years were 1998, 2005 and 2008 when the surveys were cancelled or severely curtailed due to tropical storms. Beginning in 1999 and continuing to the present, samples have been taken at 11 SEAMAP stations located off the continental shelf in the western GOM during the Fall Plankton survey.

The intended sample design for SEAMAP surveys calls for bongo sample to be taken at each site (SEAMAP station) in the systematic grid. However, over the years additional samples have been taken using SEAMAP gear and collection methods at locations other than designated SEAMAP stations. Some locations were also sampled more than once during a survey year. This year to year variability in spatial coverage during SEAMAP resource surveys was addressed by limiting observations to samples taken at SEAMAP stations that were sampled during at least 14 years of the survey time series (Figure 1). In instances where more than one sample was taken at a SEAMAP station, the sample closest to the central position of the systematic grid location was selected for inclusion in the data set. When SEAMAP stations were sampled by more than one vessel during the survey, priority was given to samples taken by the NMFS (and not the state) vessel. Only samples from the 1986-1997, 1999-2004, 2006-2007 and 2009-2010 SEAMAP Fall Plankton surveys taken in accordance with the sample design from stations sampled during at least 14 years (60%) of the time series were used to calculate the red snapper larval indices and summaries presented in this report.

Aging

Larval red snapper were obtained from samples collected during the SEAMAP summer shrimp/bottomfish trawl survey in 2008 and the fall plankton surveys in 2006, 2007, and 2008. For a description of the bottomfish trawl survey see Pollack and Ingram 2010 and Nichols 2007. Left bongo samples collected at stations located west of the mouth of the Mississippi River were used for genetic identification and ageing studies and were therefore initially preserved in 95% ETOH and transferred to fresh ethanol within 24-36 hrs. Ethanol is used to preserve these samples because formalin both degrades DNA (Goelz *et al*, 1985) and dissolves calcified structures such as otoliths (Gagliano *et al*, 2006), rendering them unsuitable for analysis.

In the cases when individuals could not be identified to the species level, the portion of the body posterior to the gut was removed from each such specimen and restored, separately, in 95% ETOH. Mitochondrial DNA (mtDNA) sequencing, as described in Greig *et al* (2005), was used to determine the species of each sample. Only those individuals identified as red snapper were used in further analysis.

The right sagittal otolith was excised for age analysis. Prior to obtaining an age estimate, the length and weight of the right otolith was measured. These data were compared to direct age estimates in order to establish relationships among these measures. Larval fish otoliths were mounted to a microscope slide, convex side up, in an epoxy resin directly after extraction. Juvenile otoliths were chosen for analysis from stations falling within an area approximately bordered by -94.5 degrees west longitude on the east, -96.5 degrees west longitude on the west, 27.5 degrees north latitude on the south, and 29.0 degrees north latitude on the north. They were then prepared for age analysis by taking a transverse section using a Buehler Isomet low speed saw and polishing each section to the primordium using 200, 400 and 600 grit sandpaper and polishing cloth with alumina powder. Daily growth increments were counted twice, independently, by a single reader, from the primordium to the edge, along the sulcus. Szedlmayer (1998) validated that increment deposition in age-0 red snapper is daily above minimum growth rates (>0.3mm/day), but that maximum growth rates are expected due to warm temperatures during spawning and development, making daily aging suitable for this species. A coefficient of variation (CV) less than 0.10 was considered acceptable and age was assigned as the mean estimate between the two counts. In the event the CV was greater than 0.10 the otolith was recounted. At this point if the CV was still greater than 0.10, a second reader was consulted, and a consensus age assigned.

Length-at-age for larval red snapper (n = 103) was modeled (Figure 1), resulting in the following relationship:

(1) $$l = 1.9302e^{0.0705t},$$

where *l* was length in mm and *t* is age in days. The *r*-squared value for this relationship was 0.8744. This relationship was used to calculate daily ages of larval red snapper collected in bongo tows during SEAMAP Fall Plankton surveys. Subsequently, the larval daily loss rate (Z = 0.1503) was estimated using the descending limb of the age distribution of the catch (Figure 2)

(Comyns *et al.* 2003), which was based on specimens ranging in size from 3.75 to 6.25 mm in length (i.e. 10 to 16 days old). Larvae < 3.75 mm and > 6.25 mm in length were excluded from analysis due to identification uncertainty of small snapper larvae and gear selectivity (Figure 3). Once ages were established, we were able to back calculate to the number of 10.5 day old larvae. However, by employing genetic identification techniques smaller larvae will be included in future estimates, and an adjustment for extrusion to account for reduced gear efficiency for smaller larvae will be made.

Index Construction

Delta-lognormal modeling methods were used to estimate relative abundance indices for larval red snapper (Lo *et al*. 1992). The main advantage of using this method is allowance for the probability of zero catch (Ortiz *et al.* 2000). The index computed by this method is a mathematical combination of yearly abundance estimates from two distinct generalized linear models: a binomial (logistic) model which describes proportion of positive abundance values (i.e. presence/absence) and a lognormal model which describes variability in only the nonzero abundance data (Lo *et al*. 1992). Overall, there were 6 abundance indices constructed for larval red snapper: Eastern Gulf of Mexico (EGOM), Western Gulf of Mexico (WGOM), entire Gulf of Mexico (GOM), Eastern Gulf of Mexico with catch adjusted to 10.5 day old larvae (EGOM-adjusted), Western Gulf of Mexico with catch adjusted to 10.5 day old larvae (WGOM-adjusted) and entire Gulf of Mexico with catch adjusted to 10.5 day old larvae (GOM-adjusted).

The delta-lognormal index of relative abundance (I_y) as described by Lo *et al*. (1992) was estimated as:

(3) $$I_y = c_y p_y,$$

where c_y is the estimate of mean CPUE for positive catches only for year y, and p_y is the estimate of mean probability of occurrence during year y. Both c_y and p_y were estimated using generalized linear models. Data used to estimate abundance for positive catches (c) and probability of occurrence (p) were assumed to have a lognormal distribution and a binomial distribution, respectively, and modeled using the following equations:

(4) $$\ln(c) = X\beta + \varepsilon$$

and

(5) $$p = \frac{e^{\mathbf{X\beta+\varepsilon}}}{1+e^{\mathbf{X\beta+\varepsilon}}},$$

respectively, where c is a vector of the positive catch data, p is a vector of the presence/absence data, X is the design matrix for main effects, β is the parameter vector for main effects, and ε is a vector of independent normally distributed errors with expectation zero and variance σ^2. Therefore, c_y and p_y were estimated as least-squares means for each year along with their corresponding standard errors, SE(c_y) and SE(p_y), respectively. From these estimates, I_y was calculated, as in equation (1), and its variance calculated as:

(6) $$V(I_y) \approx V(c_y)p_y^2 + c_y^2 V(p_y) + 2c_y p_y \mathrm{Cov}(c, p),$$

where:

(7) $$\mathrm{Cov}(c, p) \approx \rho_{c,p}\left[\mathrm{SE}(c_y)\mathrm{SE}(p_y)\right],$$

and $\rho_{c,p}$ denotes correlation of c and p among years.

The submodels of the delta-lognormal model were built using a backward selection procedure based on type 3 analyses with an inclusion level of significance of $\alpha = 0.05$. Binomial submodel performance was evaluated using Akaike's Information Criteria (AIC), while the performance of the lognormal submodel was evaluated based on analyses of residual scatter and QQ plots in addition to AIC. Variables that could be included in the submodels were: Year (1986-2010), Subregion (defined as Texas (statistical zones 18-21), Louisiana (statistical zones 13-17), Mississippi/Alabama (statistical zones 10-11) and Florida (statistical zones 1-9)), Time of Day (Day, Night) and depth (water depth at the start of the tow.

Results and Discussion

For the EGOM abundance index of larval red snapper, the nominal CPUE and number of stations with a positive catch are presented in Figure 5. Year, time of day and subregion were retained in both the binomial and lognormal submodels. Table 1 summarizes backward selection procedure used to select the final set of variables used in the submodels and their significance. The AIC for the binomial and lognormal submodels were 6175.9 and 61.5, respectively. The diagnostic plots for the binomial and lognormal submodels are shown in Figures 6-8, and indicated the distribution of the residuals is approximately normal. Annual abundance indices are presented in Table 2 and Figure 9.

For the WGOM abundance index of larval red snapper, the nominal CPUE and number of stations with a positive catch are presented in Figure 10. Year and time of day were retained in the binomial submodel, while year, time of day, subregion and depth were retained in the lognormal submodel. Table 3 summarizes backward selection procedure used to select the final set of variables used in the submodels and their significance. The AIC for the binomial and lognormal submodels were 5330.6 and 354.9, respectively. The diagnostic plots for the binomial and lognormal submodels are shown in Figures 11-13, and indicated the distribution of the residuals is approximately normal. Annual abundance indices are presented in Table 4 and Figure 14.

For the GOM abundance index of larval red snapper, the nominal CPUE and number of stations with a positive catch are presented in Figure 15. Year, time of day and subregion were retained in the binomial submodel. The variables retained in the lognormal submodel were year, time of day, subregion and depth. Table 5 summarizes backward selection procedure used to select the final set of variables used in the submodels and their significance. The AIC for the binomial and lognormal submodels were 13,796.1 and 428.2, respectively. The diagnostic plots for the binomial and lognormal submodels are shown in Figures 16-18, and indicated the distribution of the residuals is approximately normal. Annual abundance indices are presented in Table 6 and Figure 19.

For the EGOM abundance index of larval red snapper adjusted to 10.5 days old, the nominal CPUE and number of stations with a positive catch are presented in Figure 20. Year, time of day and subregion were retained in both the binomial and lognormal submodels. Table 7 summarizes backward selection procedure used to select the final set of variables used in the submodels and their significance. The AIC for the binomial and lognormal submodels were 6175.9 and 62.2, respectively. The diagnostic plots for the binomial and lognormal submodels are shown in Figures 21-23, and indicated the distribution of the residuals is approximately normal. Annual abundance indices are presented in Table 8 and Figure 24.

For the WGOM abundance index of larval red snapper adjusted to 10.5 days old, the nominal CPUE and number of stations with a positive catch are presented in Figure 25. Year and time of day were retained in the binomial submodel, while year, time of day, subregion and depth were retained in the lognormal submodel. Table 9 summarizes backward selection procedure used to select the final set of variables used in the submodels and their significance. The AIC for the binomial and lognormal submodels were 5330.6 and 395.2, respectively. The diagnostic plots for the binomial and lognormal submodels are shown in Figures 26-28, and indicated the distribution of the residuals is approximately normal. Annual abundance indices are presented in Table 10 and Figure 29.

For the GOM abundance index of larval red snapper adjusted to 10.5 days old, the nominal CPUE and number of stations with a positive catch are presented in Figure 30. Year, time of day and subregion were retained in the binomial submodel. The variables retained in the lognormal submodel were year, time of day, subregion and depth. Table 11 summarizes backward selection procedure used to select the final set of variables used in the submodels and their significance. The AIC for the binomial and lognormal submodels were 13,796.1 and 464.3, respectively. The diagnostic plots for the binomial and lognormal submodels are shown in Figures 31-33, and indicated the distribution of the residuals is approximately normal. Annual abundance indices are presented in Table 12 and Figure 34.

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Table 1. Summary of backward selection procedure for building delta-lognormal submodels for larval red snapper (Eastern Gulf of Mexico) index of relative abundance from 1986 to 2010.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 6475.4)*						*Lognormal Submodel Type 3 Tests (AIC 71.7)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	14	282	26.78	1.86	0.0205	0.0309	14	27	1.81	0.0896
Time of Day	1	296	3.74	3.74	0.0530	0.0540	1	27	4.40	0.0455
Subregion	1	314	74.03	74.03	<.0001	<.0001	1	27	10.08	0.0037
Start Water Depth	1	273	2.52	2.52	0.1121	0.1133	1	27	0.16	0.6889
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 6175.9)*						*Lognormal Submodel Type 3 Tests (AIC 61.5)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	14	282	27.32	1.89	0.0175	0.0268	14	28	2.00	0.0574
Time of Day	1	339	4.43	4.43	0.0352	0.0360	1	28	5.28	0.0293
Subregion	1	359	75.22	75.22	<.0001	<.0001	1	28	10.32	0.0033
Start Water Depth	dropped						dropped			

Table 2. Indices of larval red snapper (Eastern Gulf of Mexico) abundance developed using the delta-lognormal model for 1986-2010. The nominal frequency of occurrence, the number of samples (*N*), the DL Index (number under 10 m^2 sea surface), the DL indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

Survey Year	Frequency	*N*	DL Index	Scaled Index	CV	LCL	UCL
1986	0.00000	53					
1987	0.03509	57	0.50365	1.11770	1.74854	0.10481	11.9193
1988	0.03125	32	0.19818	0.43980	2.55352	0.02567	7.5340
1989	0.00000	34					
1990	0.00000	39					
1991	0.04651	43	0.26490	0.58786	1.19126	0.08972	3.8517
1992	0.00000	46					
1993	0.00000	50					
1994	0.01639	61	0.03089	0.06856	1.64073	0.00697	0.6742
1995	0.03448	58	0.09298	0.20633	1.62099	0.02131	1.9978
1996	0.00000	61					
1997	0.01695	59	0.04013	0.08906	3.43459	0.00365	2.1701
1998							
1999	0.05085	59	0.27158	0.60269	0.55390	0.21418	1.6959
2000	0.06780	59	0.69739	1.54764	1.29270	0.21317	11.2361
2001	0.05085	59	0.22636	0.50234	0.88087	0.11034	2.2869
2002	0.02564	39	0.10509	0.23322	2.76791	0.01235	4.4054
2003	0.06667	60	0.37985	0.84295	0.90995	0.17832	3.9848
2004	0.00000	41					
2005							
2006	0.05085	59	0.53091	1.17819	1.17349	0.18322	7.5763
2007	0.09677	62	0.60553	1.34379	0.45607	0.56332	3.2056
2008							
2009	0.06452	62	0.56093	1.24480	1.05438	0.22087	7.0156
2010	0.13333	60	2.25088	4.99510	0.41621	2.24578	11.1102

Table 3. Summary of backward selection procedure for building delta-lognormal submodels for larval red snapper (Western Gulf of Mexico) index of relative abundance from 1986 to 2010.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 5348.5)*						*Lognormal Submodel Type 3 Tests (AIC 354.9)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	20	342	37.65	1.82	0.0098	0.0180	20	160	2.02	0.0087
Time of Day	1	901	36.90	36.90	<.0001	<.0001	1	160	6.97	0.0091
Subregion	1	924	0.13	0.13	0.7204	0.7205	1	160	4.38	0.0380
Start Water Depth	1	630	1.45	1.45	0.2280	0.2285	1	160	9.31	0.0027
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 5348.7)*						*Lognormal Submodel Type 3 Tests (AIC 354.9)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	20	342	37.47	1.81	0.0103	0.0187	20	160	2.02	0.0087
Time of Day	1	900	36.98	36.98	<.0001	<.0001	1	160	6.97	0.0091
Subregion				dropped			1	160	4.38	0.0380
Start Water Depth	1	625	1.68	1.68	0.1954	0.1958	1	160	9.31	0.0027
Model Run #3	*Binomial Submodel Type 3 Tests (AIC 5330.6)*						*Lognormal Submodel Type 3 Tests (AIC 354.9)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	20	343	37.84	1.83	0.0093	0.0172	20	160	2.02	0.0087
Time of Day	1	904	36.96	36.96	<.0001	<.0001	1	160	6.97	0.0091
Subregion				dropped			1	160	4.38	0.0380
Start Water Depth				dropped			1	160	9.31	0.0027

Table 4. Indices of larval red snapper (Western Gulf of Mexico) abundance developed using the delta-lognormal model for 1986-2010. The nominal frequency of occurrence, the number of samples (*N*), the DL Index (number under 10 m^2 sea surface), the DL indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

Survey Year	Frequency	*N*	DL Index	Scaled Index	CV	LCL	UCL
1986	0.08163	49	0.32309	0.27198	0.62151	0.08672	0.85298
1987	0.05455	55	0.80713	0.67943	0.74914	0.17882	2.58147
1988	0.00000	28					
1989	0.10714	28	0.69775	0.58736	0.69915	0.16632	2.07424
1990	0.16129	31	0.87793	0.73904	0.51368	0.28077	1.94531
1991	0.09677	31	0.42961	0.36164	0.61563	0.11638	1.12374
1992	0.12727	55	0.47747	0.40193	0.39181	0.18876	0.85585
1993	0.12727	55	0.49076	0.41312	0.35355	0.20796	0.82067
1994	0.07273	55	0.78682	0.66234	0.66790	0.19659	2.23157
1995	0.21818	55	1.93443	1.62839	0.33628	0.84616	3.13374
1996	0.16364	55	1.06297	0.89480	0.35614	0.44831	1.78599
1997	0.24074	54	1.61207	1.35703	0.29564	0.76061	2.42111
1998							
1999	0.10909	55	0.46715	0.39325	0.41993	0.17564	0.88045
2000	0.25455	55	1.74748	1.47102	0.29778	0.82119	2.63505
2001	0.12766	47	1.15579	0.97293	0.46572	0.40110	2.36003
2002	0.22222	54	1.43024	1.20397	0.31244	0.65393	2.21668
2003	0.29630	54	2.15713	1.81586	0.29399	1.02094	3.22971
2004	0.18519	54	1.03342	0.86993	0.31423	0.47092	1.60701
2005							
2006	0.21154	52	2.64306	2.22491	0.38554	1.05673	4.68445
2007	0.27778	54	1.52920	1.28727	0.27163	0.75496	2.19490
2008							
2009	0.29091	55	2.26372	1.90559	0.25305	1.15780	3.13633
2010	0.14815	54	1.01952	0.85822	0.43519	0.37314	1.97393

Table 5. Summary of backward selection procedure for building delta-lognormal submodels for larval red snapper (Gulf of Mexico) index of relative abundance from 1986 to 2010.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 13796.7)*						*Lognormal Submodel Type 3 Tests (AIC 428.2)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	21	748	59.92	2.80	<.0001	<.0001	21	202	1.69	0.0346
Time of Day	1	1837	43.44	43.44	<.0001	<.0001	1	202	13.57	0.0003
Subregion	3	1819	97.62	32.54	<.0001	<.0001	3	202	5.33	0.0015
Start Water Depth	1	1190	0.47	0.47	0.4939	0.4940	1	202	8.62	0.0037
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 13796.1)*						*Lognormal Submodel Type 3 Tests (AIC 428.2)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	21	749	60.41	2.83	<.0001	<.0001	21	202	1.69	0.0346
Time of Day	1	1837	43.47	43.47	<.0001	<.0001	1	202	13.57	0.0003
Subregion	3	1816	97.26	32.42	<.0001	<.0001	3	202	5.33	0.0015
Start Water Depth	dropped						1	202	8.62	0.0037

Table 6. Indices of larval red snapper (Gulf of Mexico) abundance developed using the delta-lognormal model for 1986-2010. The nominal frequency of occurrence, the number of samples (*N*), the DL Index (number under 10 m^2 sea surface), the DL indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

Survey Year	Frequency	*N*	DL Index	Scaled Index	CV	LCL	UCL
1986	0.03922	102	0.14379	0.25784	0.60098	0.08493	0.78285
1987	0.04464	112	0.38936	0.69822	1.25703	0.09962	4.89350
1988	0.01667	60	0.07803	0.13992	2.69511	0.00765	2.55936
1989	0.04839	62	0.23511	0.42160	0.65465	0.12769	1.39200
1990	0.07143	70	0.34569	0.61991	0.46307	0.25673	1.49683
1991	0.06757	74	0.32527	0.58328	0.64758	0.17859	1.90499
1992	0.06931	101	0.20543	0.36839	0.41924	0.16474	0.82379
1993	0.06667	105	0.20582	0.36909	0.39133	0.17348	0.78523
1994	0.04310	116	0.20724	0.37163	0.42786	0.16368	0.84381
1995	0.12389	113	0.64395	1.15475	0.30435	0.63674	2.09415
1996	0.07759	116	0.41144	0.73781	0.33974	0.38095	1.42893
1997	0.12389	113	0.65886	1.18149	0.30895	0.64591	2.16116
1998							
1999	0.07895	114	0.32851	0.58910	0.38388	0.28064	1.23662
2000	0.15789	114	0.95418	1.71106	0.39371	0.80083	3.65589
2001	0.08491	106	0.47626	0.85404	0.43261	0.37300	1.95544
2002	0.13978	93	0.59349	1.06426	0.33895	0.55031	2.05821
2003	0.17544	114	1.01725	1.82416	0.29005	1.03323	3.22056
2004	0.10526	95	0.41360	0.74169	0.34960	0.37608	1.46274
2005							
2006	0.12613	111	1.21117	2.17191	0.39195	1.01973	4.62594
2007	0.18103	116	1.02639	1.84055	0.25023	1.12433	3.01303
2008							
2009	0.17094	117	1.26757	2.27304	0.32092	1.21525	4.25159
2010	0.14035	114	1.12994	2.02625	0.40276	0.93308	4.40014

Table 7. Summary of backward selection procedure for building delta-lognormal submodels for larval red snapper adjusted to 10.5 days old (Eastern Gulf of Mexico) index of relative abundance from 1986 to 2010.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 6475.4)*						*Lognormal Submodel Type 3 Tests (AIC 72.2)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	14	282	26.78	1.86	0.0205	0.0309	14	27	3.09	0.0057
Time of Day	1	296	3.74	3.74	0.0530	0.0540	1	27	5.28	0.0295
Subregion	1	314	74.03	74.03	<.0001	<.0001	1	27	13.48	0.0010
Start Water Depth	1	273	2.52	2.52	0.1121	0.1133	1	27	0.37	0.5464
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 6175.9)*						*Lognormal Submodel Type 3 Tests (AIC 62.2)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	14	282	27.32	1.89	0.0175	0.0268	14	28	3.41	0.0028
Time of Day	1	339	4.43	4.43	0.0352	0.0360	1	28	6.51	0.0165
Subregion	1	359	75.22	75.22	<.0001	<.0001	1	28	13.67	0.0009
Start Water Depth	dropped						dropped			

Table 8. Indices of larval red snapper adjusted to 10.5 days old (Eastern Gulf of Mexico) abundance developed using the delta-lognormal model for 1986-2010. The nominal frequency of occurrence, the number of samples (*N*), the DL Index (number under 10 m^2 sea surface), the DL indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

Survey Year	Frequency	*N*	DL Index	Scaled Index	CV	LCL	UCL
1986	0.00000	53					
1987	0.03509	57	0.69073	1.04863	1.74530	0.09856	11.1563
1988	0.03125	32	0.25739	0.39076	2.55931	0.02275	6.7124
1989	0.00000	34					
1990	0.00000	39					
1991	0.04651	43	0.33057	0.50186	1.20183	0.07576	3.3247
1992	0.00000	46					
1993	0.00000	50					
1994	0.01639	61	0.02796	0.04245	1.92914	0.00351	0.5128
1995	0.03448	58	0.11299	0.17153	1.65608	0.01724	1.7069
1996	0.00000	61					
1997	0.01695	59	0.04055	0.06156	3.75865	0.00228	1.6631
1998							
1999	0.05085	59	0.41450	0.62927	0.54199	0.22805	1.7364
2000	0.06780	59	1.23632	1.87692	1.27867	0.26211	13.4405
2001	0.05085	59	0.26089	0.39607	0.90346	0.08448	1.8568
2002	0.02564	39	0.10619	0.16121	2.93314	0.00796	3.2643
2003	0.06667	60	0.53121	0.80646	0.90566	0.17154	3.7914
2004	0.00000	41					
2005							
2006	0.05085	59	0.73577	1.11700	1.17061	0.17424	7.1609
2007	0.09677	62	0.78980	1.19903	0.45786	0.50108	2.8692
2008							
2009	0.06452	62	0.64359	0.97707	1.06492	0.17127	5.5739
2010	0.13333	60	3.70199	5.62017	0.41504	2.53209	12.4744

Table 9. Summary of backward selection procedure for building delta-lognormal submodels for larval red snapper adjusted to 10.5 days old (Western Gulf of Mexico) index of relative abundance from 1986 to 2010.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 5348.5)*						*Lognormal Submodel Type 3 Tests (AIC 395.2)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	20	342	37.65	1.82	0.0098	0.0180	20	160	1.37	0.1423
Time of Day	1	901	36.90	36.90	<.0001	<.0001	1	160	8.62	0.0038
Subregion	1	924	0.13	0.13	0.7204	0.7205	1	160	4.18	0.0426
Start Water Depth	1	630	1.45	1.45	0.2280	0.2285	1	160	5.11	0.0251
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 5348.7)*						*Lognormal Submodel Type 3 Tests (AIC 395.2)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	20	342	37.47	1.81	0.0103	0.0187	20	160	1.37	0.1423
Time of Day	1	900	36.98	36.98	<.0001	<.0001	1	160	8.62	0.0038
Subregion				dropped			1	161	6.02	0.0152
Start Water Depth	1	625	1.68	1.68	0.1954	0.1958	1	160	5.11	0.0251
Model Run #3	*Binomial Submodel Type 3 Tests (AIC 5330.6)*						*Lognormal Submodel Type 3 Tests (AIC 395.2)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	20	343	37.84	1.83	0.0093	0.0172	20	160	1.37	0.1423
Time of Day	1	904	36.96	36.96	<.0001	<.0001	1	160	8.62	0.0038
Subregion				dropped			1	161	6.02	0.0152
Start Water Depth				dropped			1	160	5.11	0.0251

Table 10. Indices of larval red snapper adjusted to 10.5 days old (Western Gulf of Mexico) abundance developed using the delta-lognormal model for 1986-2010. The nominal frequency of occurrence, the number of samples (*N*), the DL Index (number under 10 m^2 sea surface), the DL indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

Survey Year	Frequency	*N*	DL Index	Scaled Index	CV	LCL	UCL
1986	0.08163	49	0.55082	0.33213	0.64284	0.10244	1.07682
1987	0.05455	55	1.12050	0.67563	0.76236	0.17449	2.61607
1988	0.00000	28					
1989	0.10714	28	0.76536	0.46149	0.73397	0.12416	1.71539
1990	0.16129	31	0.97317	0.58680	0.52245	0.21968	1.56744
1991	0.09677	31	0.52320	0.31548	0.69305	0.09015	1.10399
1992	0.12727	55	0.78233	0.47173	0.40875	0.21492	1.03539
1993	0.12727	55	0.69829	0.42105	0.37141	0.20516	0.86411
1994	0.07273	55	0.89670	0.54069	0.64868	0.16527	1.76889
1995	0.21818	55	2.59062	1.56208	0.33992	0.80628	3.02636
1996	0.16364	55	1.34897	0.81339	0.35454	0.40871	1.61877
1997	0.24074	54	2.22598	1.34221	0.30722	0.73616	2.44721
1998							
1999	0.10909	55	0.78519	0.47345	0.45930	0.19736	1.13576
2000	0.25455	55	2.65834	1.60291	0.31289	0.86987	2.95369
2001	0.12766	47	1.76149	1.06213	0.47675	0.42963	2.62584
2002	0.22222	54	1.84153	1.11040	0.33538	0.57796	2.13335
2003	0.29630	54	2.94472	1.77559	0.29355	0.99912	3.15551
2004	0.18519	54	1.46000	0.88034	0.33654	0.45724	1.69497
2005							
2006	0.21154	52	3.65686	2.20500	0.40688	1.00795	4.82366
2007	0.27778	54	2.40870	1.45239	0.29172	0.82007	2.57225
2008							
2009	0.29091	55	3.31769	2.00049	0.25489	1.21121	3.30409
2010	0.14815	54	1.51685	0.91462	0.41896	0.40921	2.04427

Table 11. Summary of backward selection procedure for building delta-lognormal submodels for larval red snapper adjusted to 10.5 days old (Gulf of Mexico) index of relative abundance from 1986 to 2010.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 13796.7)*						*Lognormal Submodel Type 3 Tests (AIC 464.3)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	21	748	59.92	2.80	<.0001	<.0001	21	202	1.76	0.0245
Time of Day	1	1837	43.44	43.44	<.0001	<.0001	1	202	13.85	0.0003
Subregion	3	1819	97.62	32.54	<.0001	<.0001	3	202	5.68	0.0009
Start Water Depth	1	1190	0.47	0.47	0.4939	0.4940	1	202	5.87	0.0163
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 13796.1)*						*Lognormal Submodel Type 3 Tests (AIC 464.3)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	21	749	60.41	2.83	<.0001	<.0001	21	202	1.76	0.0245
Time of Day	1	1837	43.47	43.47	<.0001	<.0001	1	202	13.85	0.0003
Subregion	3	1816	97.26	32.42	<.0001	<.0001	3	202	5.68	0.0009
Start Water Depth				dropped			1	202	5.87	0.0163

Table 12. Indices of larval red snapper adjusted to 10.5 days old (Gulf of Mexico) abundance developed using the delta-lognormal model for 1986-2010. The nominal frequency of occurrence, the number of samples (*N*), the DL Index (number under 10 m^2 sea surface), the DL indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

Survey Year	Frequency	*N*	DL Index	Scaled Index	CV	LCL	UCL
1986	0.03922	102	1.6787	0.35079	0.61872	0.11234	1.09534
1987	0.04464	112	3.6539	0.76354	1.26372	0.10822	5.38720
1988	0.01667	60	0.5619	0.11742	2.52308	0.00696	1.98228
1989	0.04839	62	1.0250	0.21419	0.70279	0.06032	0.76050
1990	0.07143	70	1.6215	0.33883	0.51693	0.12802	0.89677
1991	0.06757	74	1.9043	0.39792	0.67884	0.11616	1.36308
1992	0.06931	101	2.2677	0.47386	0.45114	0.20036	1.12073
1993	0.06667	105	1.7261	0.36069	0.42917	0.15849	0.82087
1994	0.04310	116	1.2434	0.25982	0.47901	0.10469	0.64482
1995	0.12389	113	5.0891	1.06342	0.34051	0.54829	2.06252
1996	0.07759	116	3.0358	0.63438	0.38502	0.30159	1.33439
1997	0.12389	113	4.8959	1.02307	0.34404	0.52407	1.99719
1998							
1999	0.07895	114	3.5853	0.74919	0.41993	0.33462	1.67738
2000	0.15789	114	10.5277	2.19990	0.41634	0.98884	4.89418
2001	0.08491	106	3.8581	0.80619	0.46692	0.33166	1.95964
2002	0.13978	93	3.5013	0.73164	0.37269	0.35567	1.50503
2003	0.17544	114	8.6305	1.80345	0.31842	0.96868	3.35758
2004	0.10526	95	3.6083	0.75400	0.38952	0.35556	1.59894
2005							
2006	0.12613	111	8.6903	1.81594	0.42159	0.80869	4.07777
2007	0.18103	116	8.7198	1.82212	0.28236	1.04716	3.17059
2008							
2009	0.17094	117	11.1023	2.31995	0.34689	1.18220	4.55269
2010	0.14035	114	14.3552	2.99970	0.42885	1.31882	6.82290

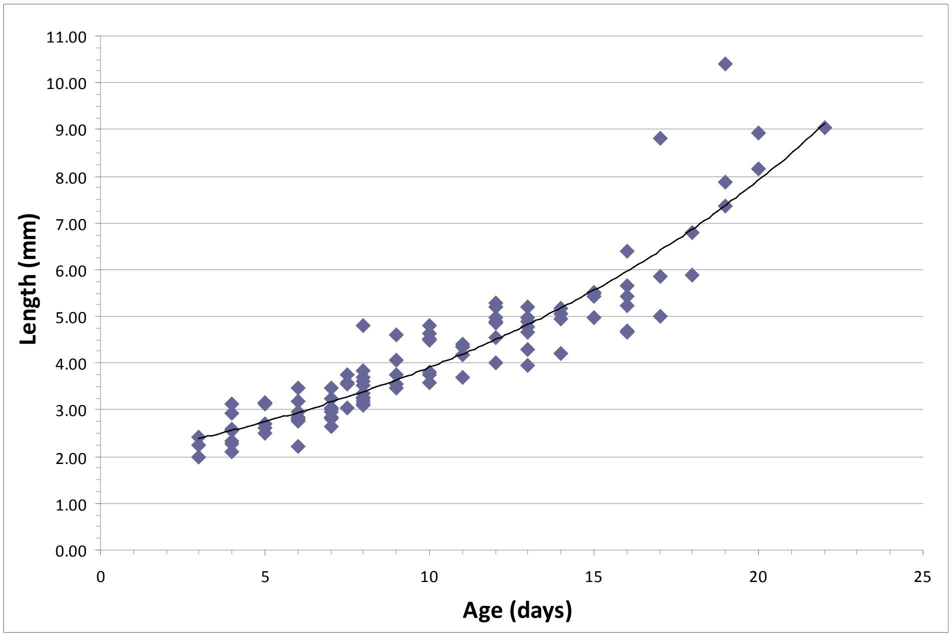


Figure 1. Length versus age for larval red snapper (n = 103).

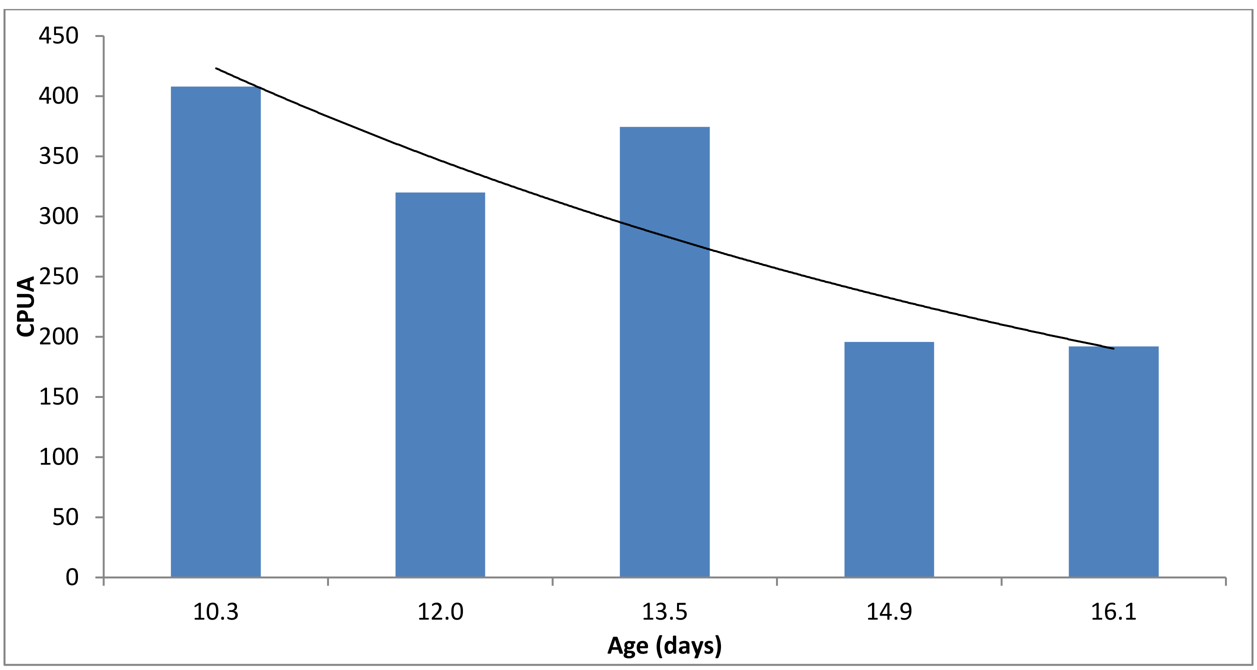


Figure 2. Age distribution (age of the size class midpoint) of the larval red snapper catch and the resulting daily loss rate curve (Z = 0.1503).

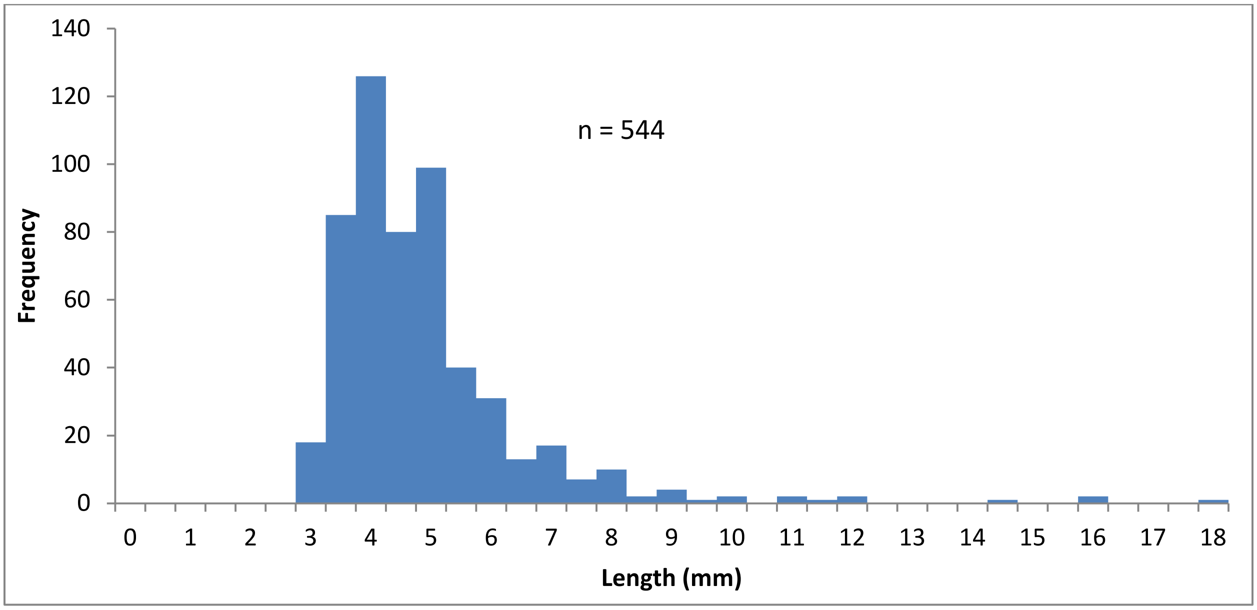


Figure 3. Length frequency histogram displaying catch sizes of larval red snapper caught during SEAMAP Fall Plankton surveys.

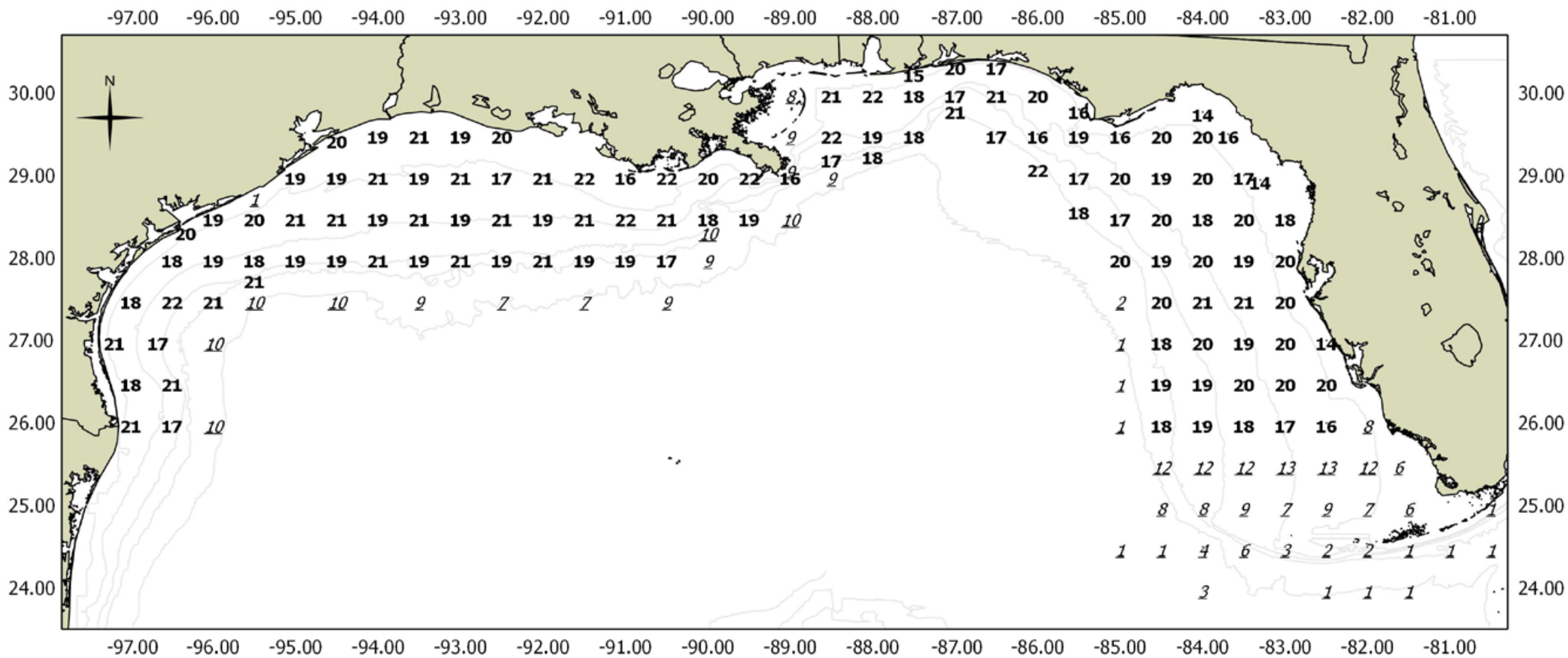


Figure 4. Number of samples taken at each SEAMAP B-number location from 1986-2010 during the SEAMAP Fall Plankton Survey. Bold numbers represent locations that were sampled at least 14 times (60%) during the survey, and were included in analysis while those underlined and in italics were not included in the analysis.

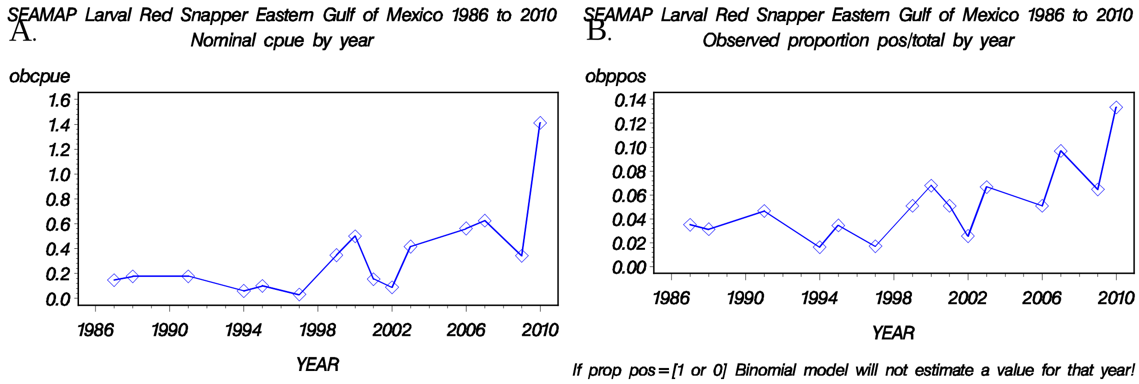


Figure 5. Annual trends for larval red snapper captured during the SEAMAP Fall Plankton Survey (Eastern Gulf of Mexico) from 1986 to 2010 in **A.** nominal CPUE and **B.** proportion of positive stations.

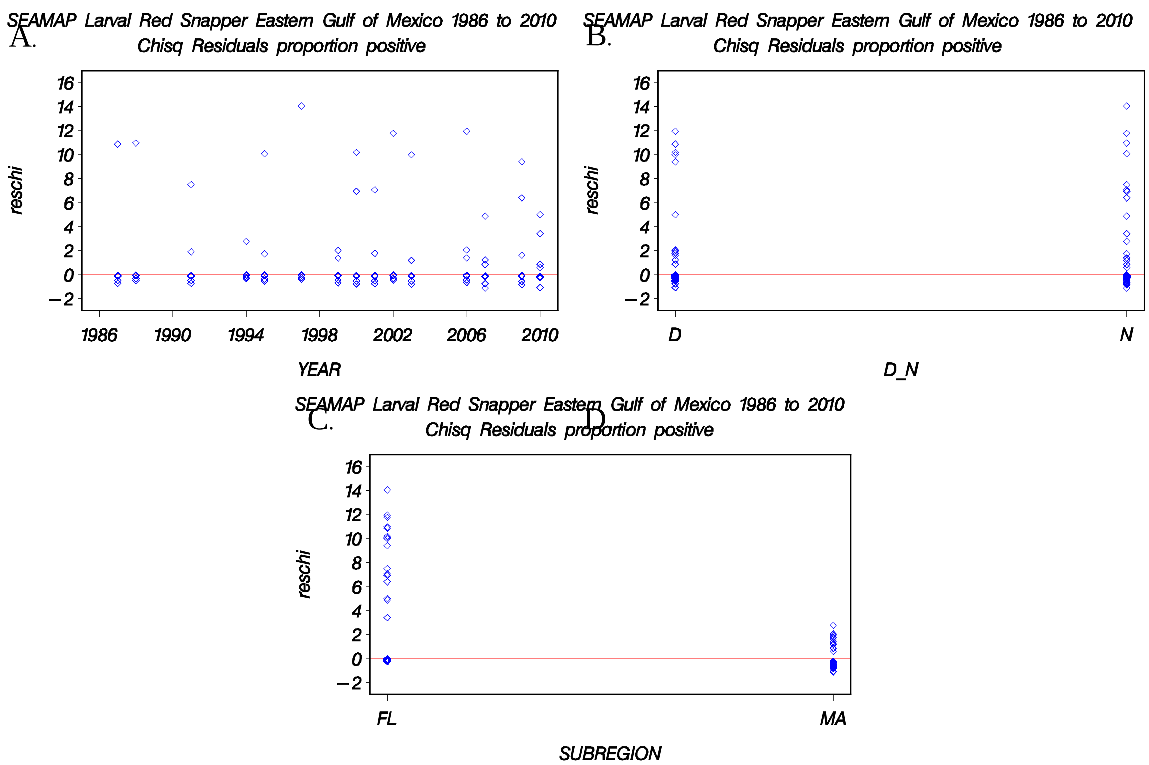


Figure 6. Diagnostic plots for binomial component of the larval red snapper SEAMAP Fall Plankton Survey (Eastern Gulf of Mexico) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by time of day and **C.** the Chi-Square residuals by subregion.

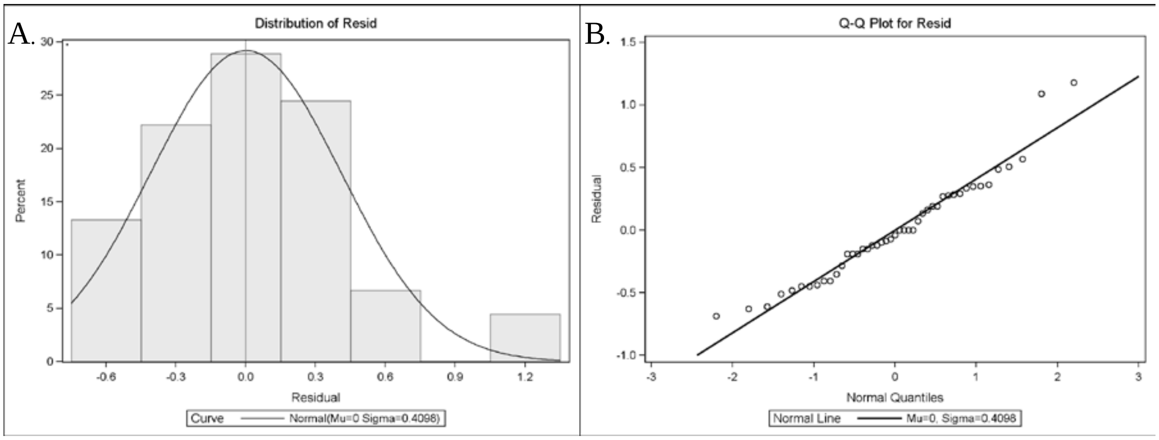


Figure 7. Diagnostic plots for lognormal component of the larval red snapper SEAMAP Fall Plankton Survey (Eastern Gulf of Mexico) model: **A.** the frequency distribution of log(CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

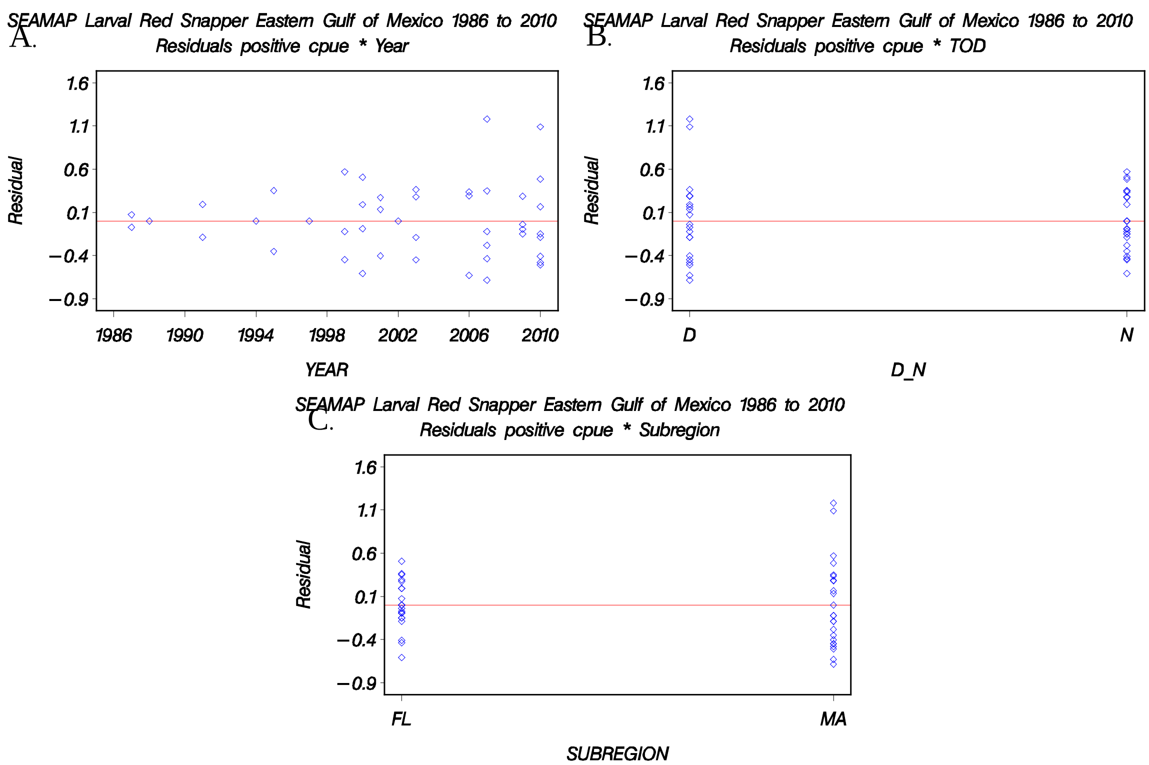


Figure 8. Diagnostic plots for lognormal component of the larval red snapper SEAMAP Fall Plankton Survey (Eastern Gulf of Mexico) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by time of day and **C.** the Chi-Square residuals by subregion.

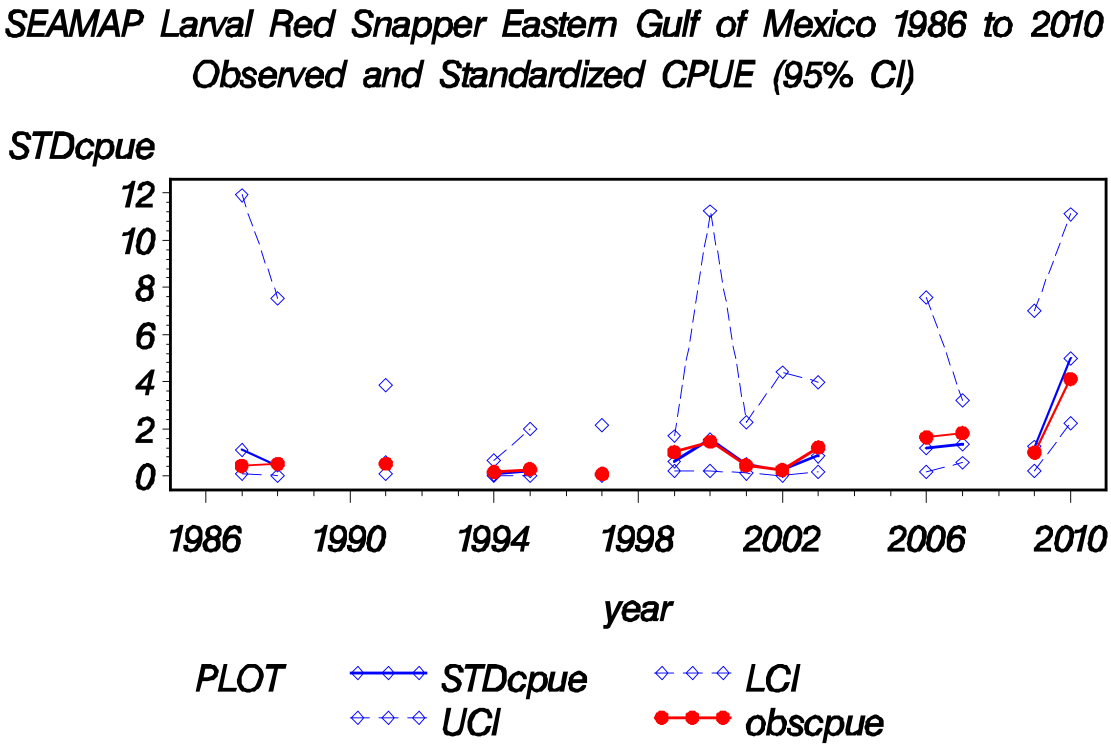


Figure 9. Annual index of abundance for larval red snapper (Eastern Gulf of Mexico) from the SEAMAP Fall Plankton Survey from 1986 – 2010.

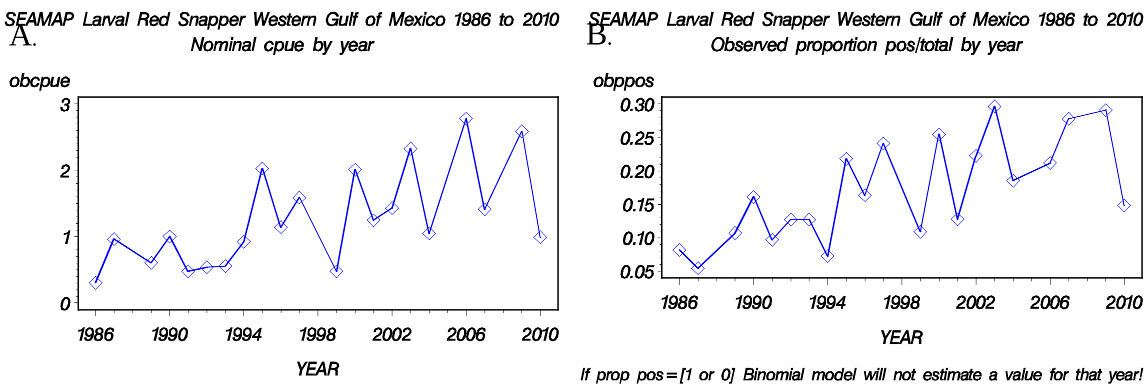


Figure 10. Annual trends for larval red snapper captured during the SEAMAP Fall Plankton Survey (Western Gulf of Mexico) from 1986 to 2010 in **A.** nominal CPUE and **B.** proportion of positive stations.

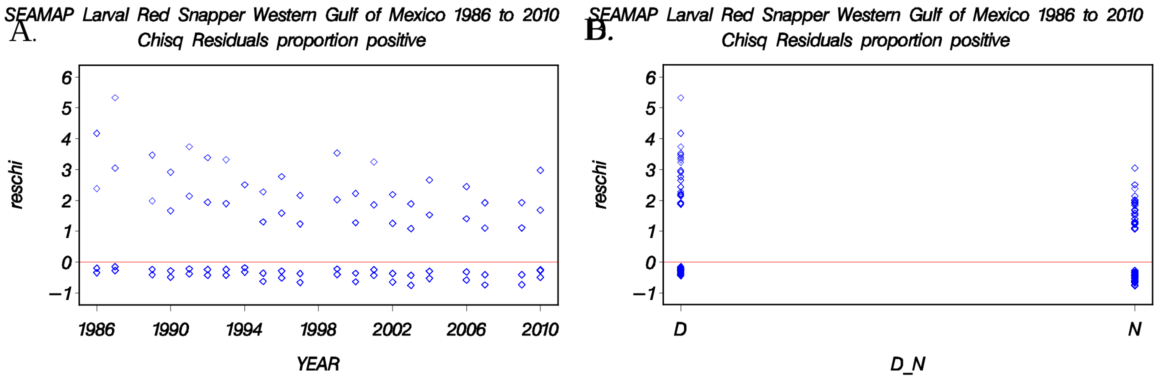


Figure 11. Diagnostic plots for binomial component of the larval red snapper SEAMAP Fall Plankton Survey (Western Gulf of Mexico) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by time of day and **C.** the Chi-Square residuals by subregion.

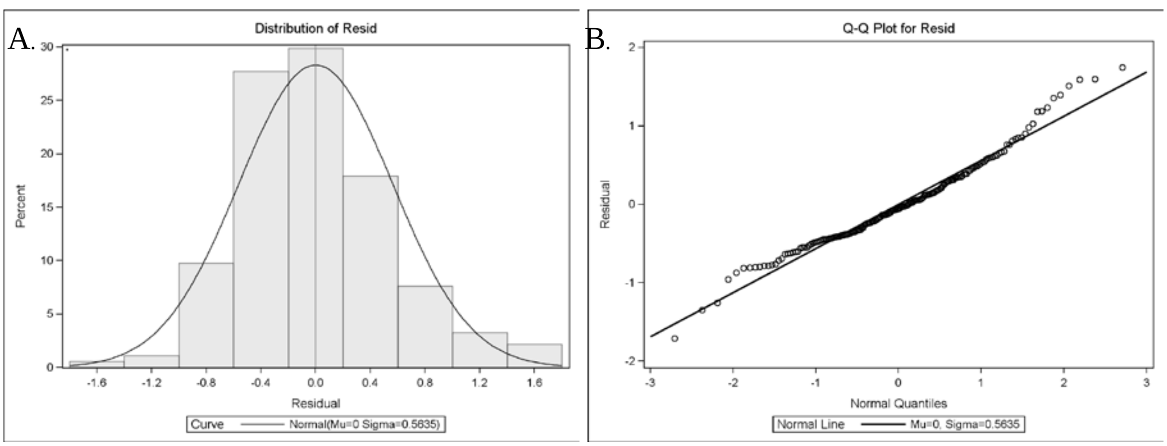


Figure 12. Diagnostic plots for lognormal component of the larval red snapper SEAMAP Fall Plankton Survey (Western Gulf of Mexico) model: **A.** the frequency distribution of log(CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

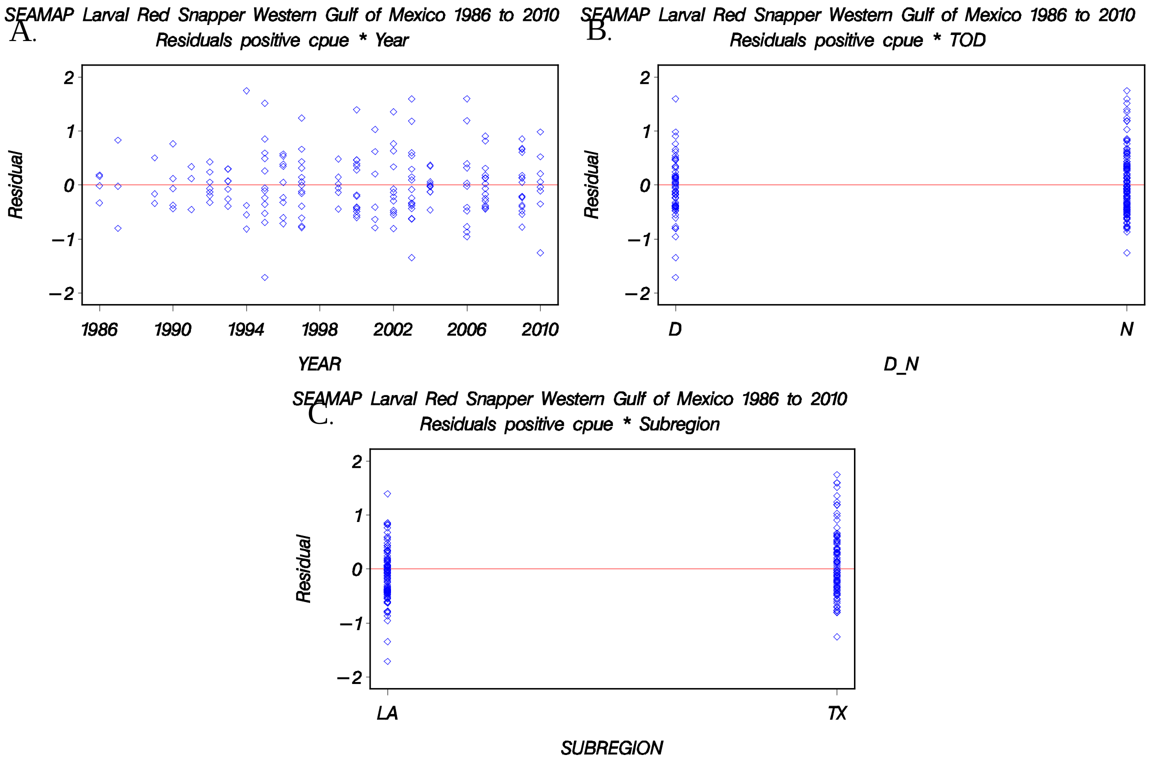


Figure 13. Diagnostic plots for lognormal component of the larval red snapper SEAMAP Fall Plankton Survey (Western Gulf of Mexico) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by time of day and **C.** the Chi-Square residuals by subregion.

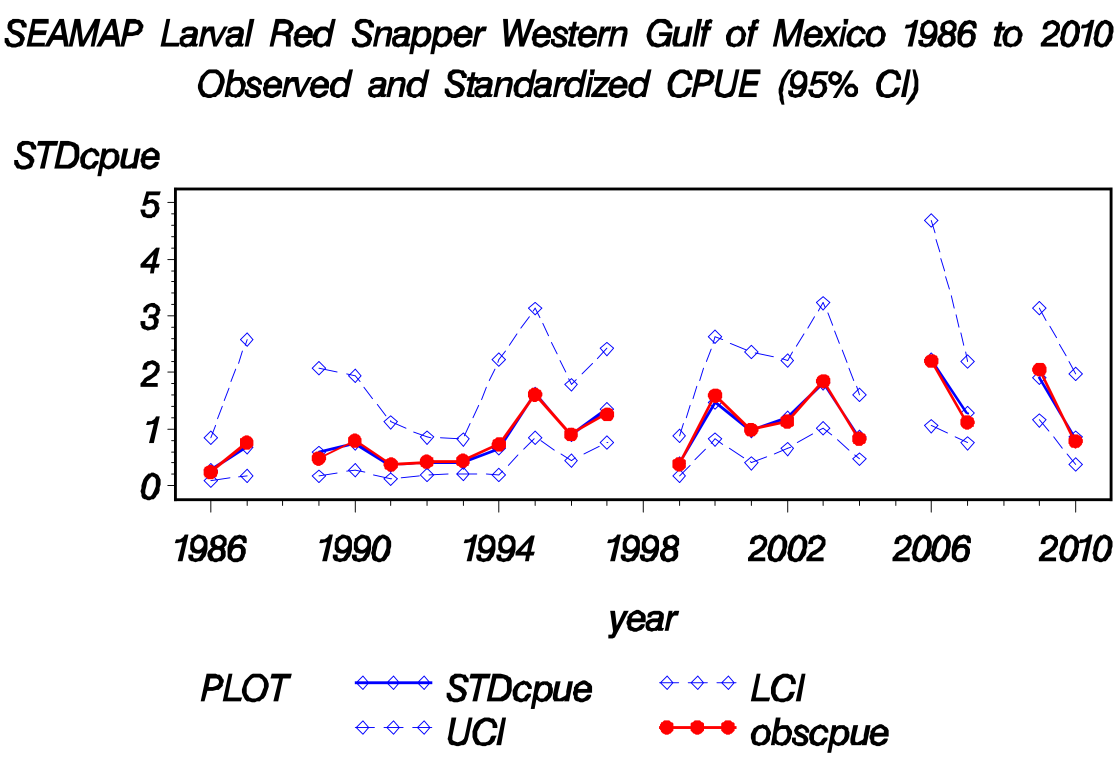


Figure 14. Annual index of abundance for larval red snapper (Western Gulf of Mexico) from the SEAMAP Fall Plankton Survey from 1986 – 2010.

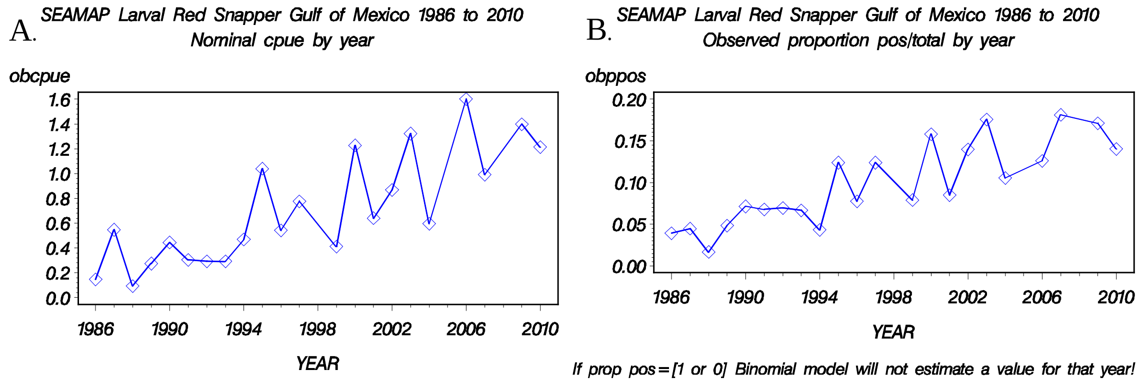


Figure 15. Annual trends for larval red snapper captured during the SEAMAP Fall Plankton Survey (Gulf of Mexico) from 1986 to 2010 in **A.** nominal CPUE and **B.** proportion of positive stations.

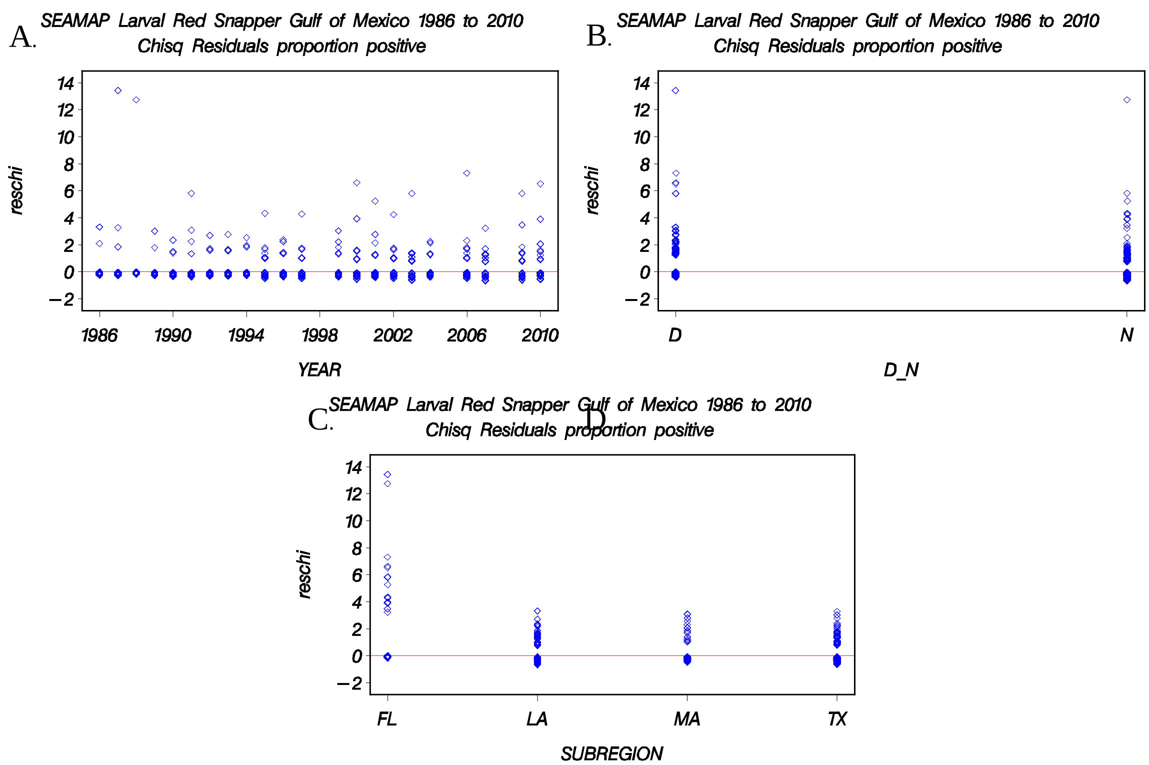


Figure 16. Diagnostic plots for binomial component of the larval red snapper SEAMAP Fall Plankton Survey (Gulf of Mexico) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by time of day and **C.** the Chi-Square residuals by subregion.

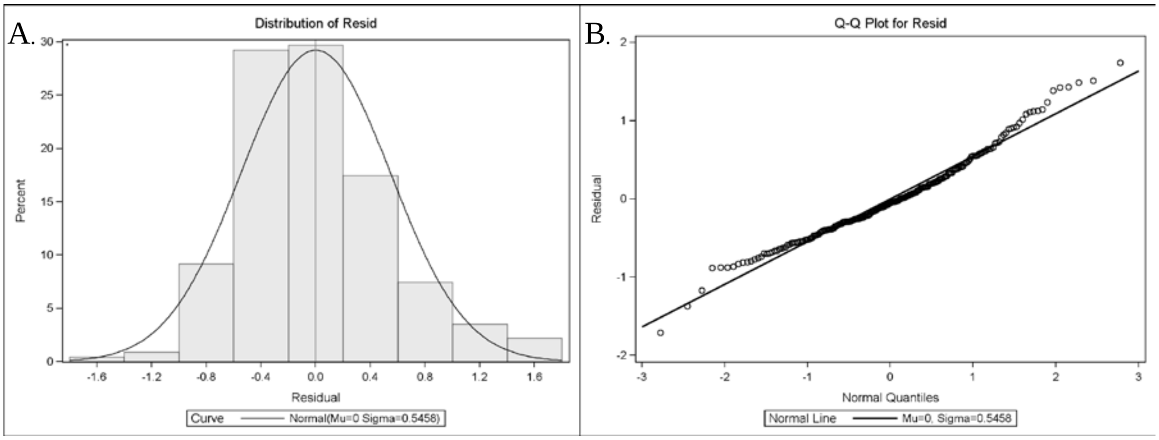


Figure 17. Diagnostic plots for lognormal component of the larval red snapper SEAMAP Fall Plankton Survey (Gulf of Mexico) model: **A.** the frequency distribution of log(CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

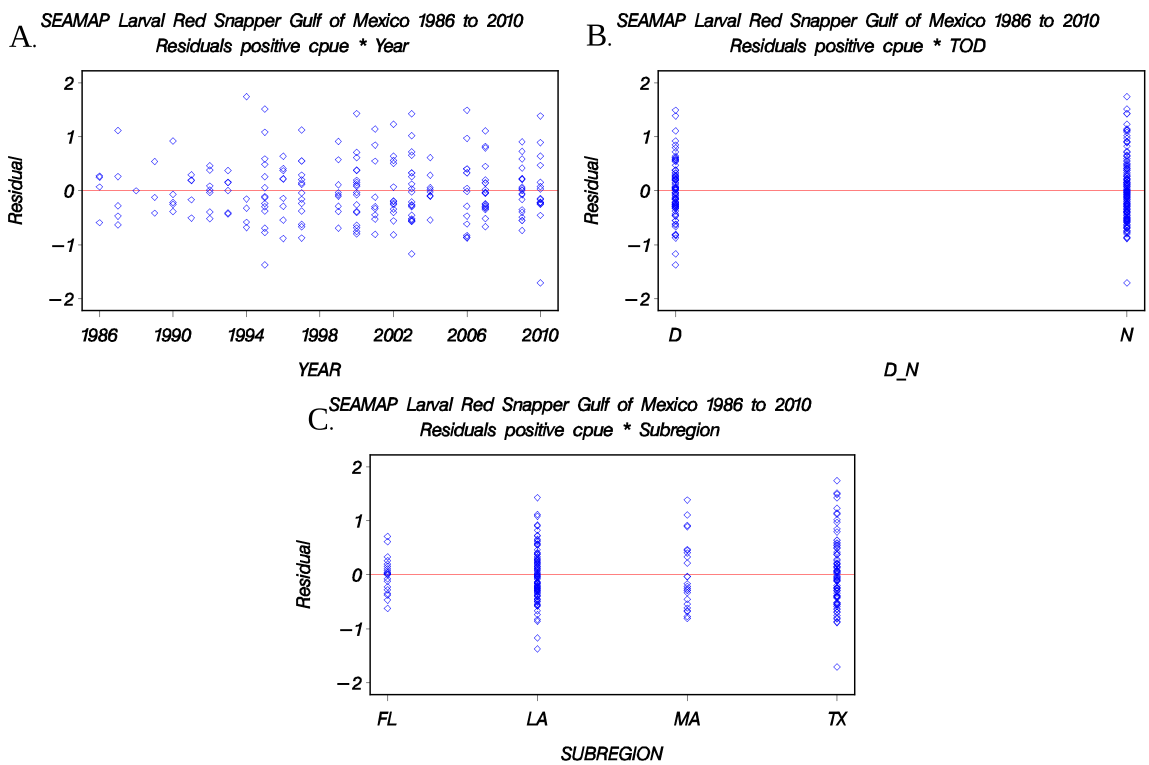


Figure 18. Diagnostic plots for lognormal component of the larval red snapper SEAMAP Fall Plankton Survey (Gulf of Mexico) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by time of day and **C.** the Chi-Square residuals by subregion.

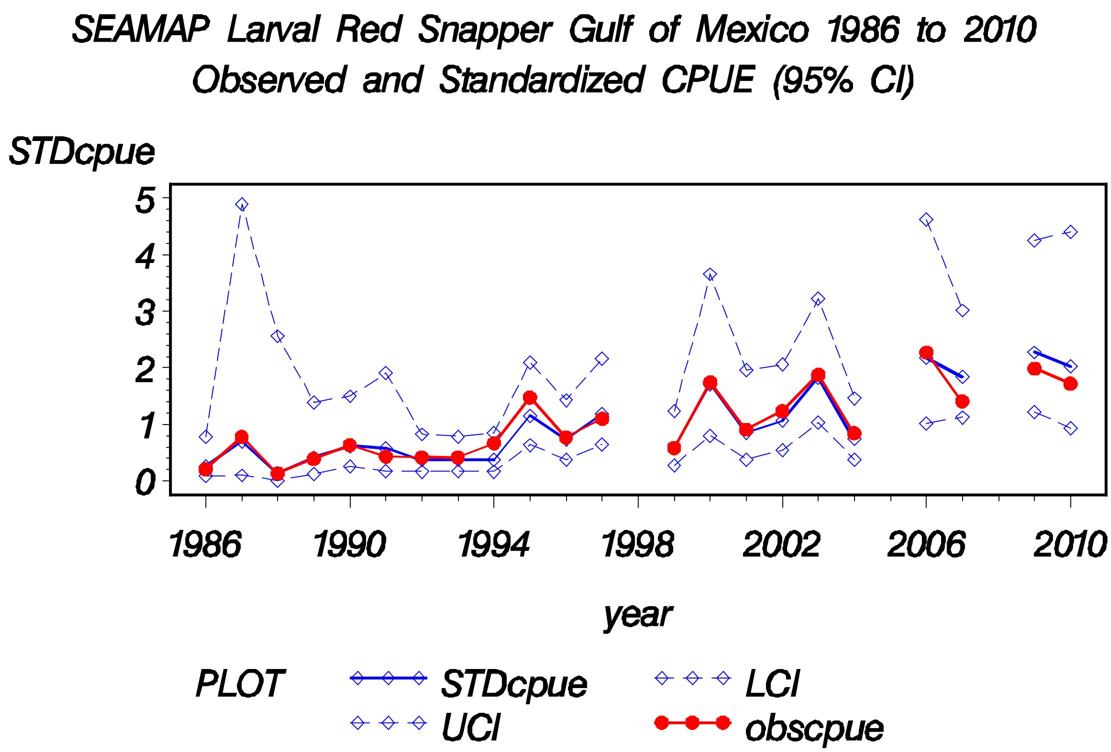


Figure 19. Annual index of abundance for larval red snapper (Gulf of Mexico) from the SEAMAP Fall Plankton Survey from 1986 – 2010.

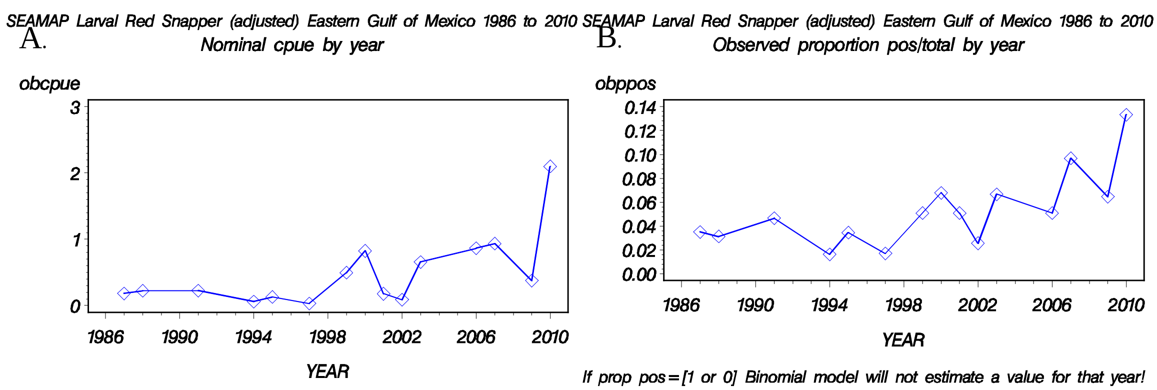


Figure 20. Annual trends for larval red snapper adjusted to 10.5 days old captured during the SEAMAP Fall Plankton Survey (Eastern Gulf of Mexico) from 1986 to 2010 in **A.** nominal CPUE and **B.** proportion of positive stations.

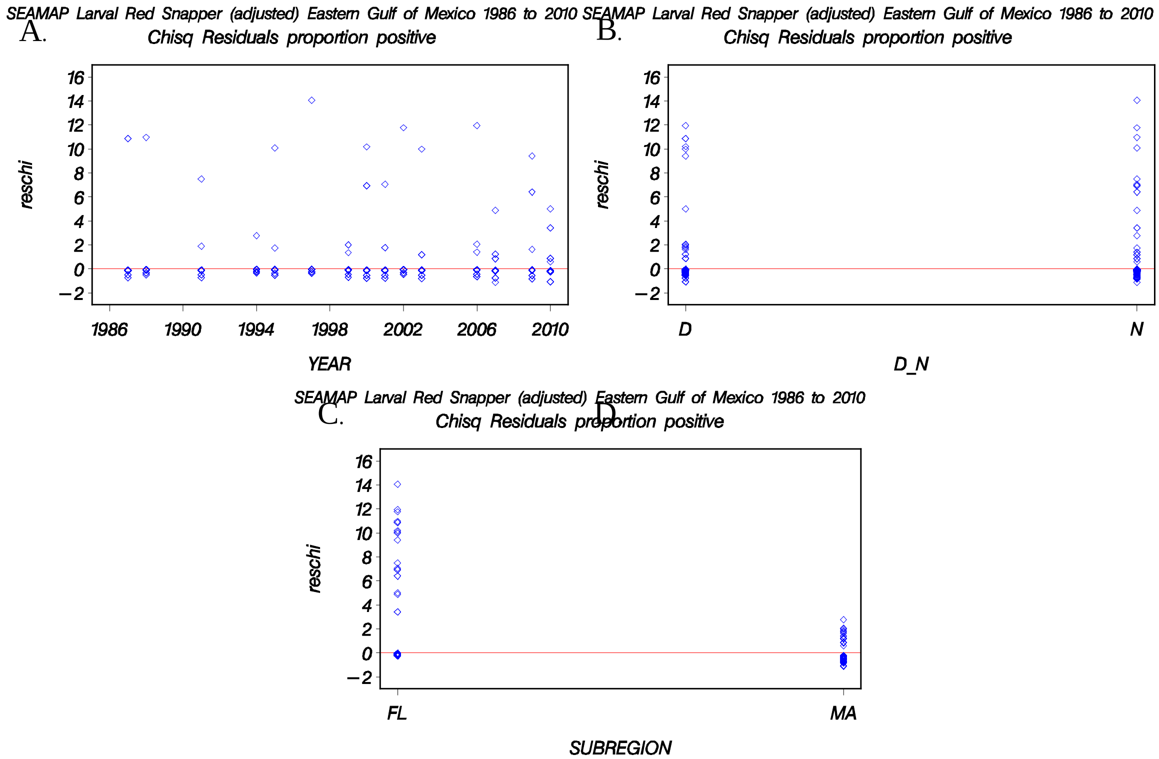


Figure 21. Diagnostic plots for binomial component of the larval red snapper adjusted to 10.5 days old SEAMAP Fall Plankton Survey (Eastern Gulf of Mexico) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by time of day and **C.** the Chi-Square residuals by subregion.

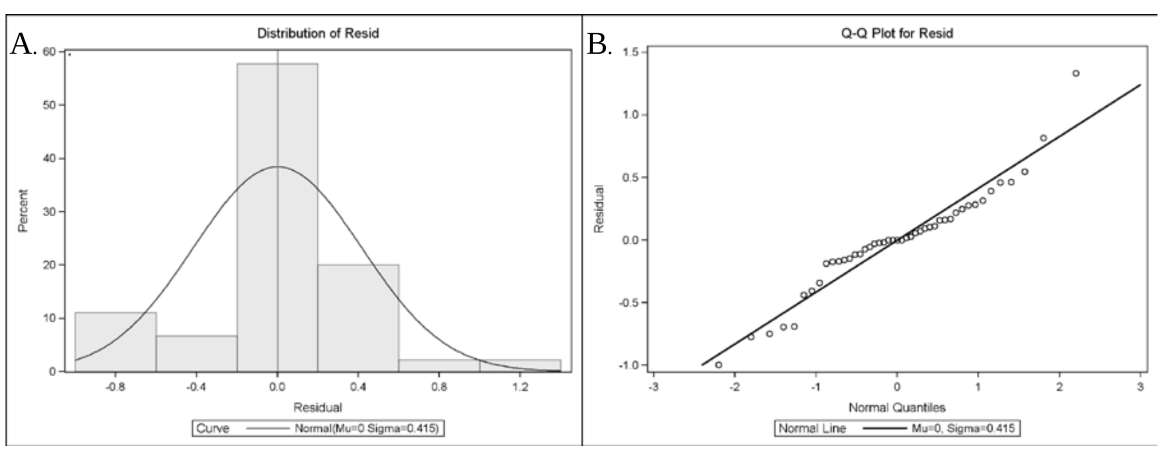


Figure 22. Diagnostic plots for lognormal component of the larval red snapper adjusted to 10.5 days old SEAMAP Fall Plankton Survey (Eastern Gulf of Mexico) model: **A.** the frequency distribution of log(CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

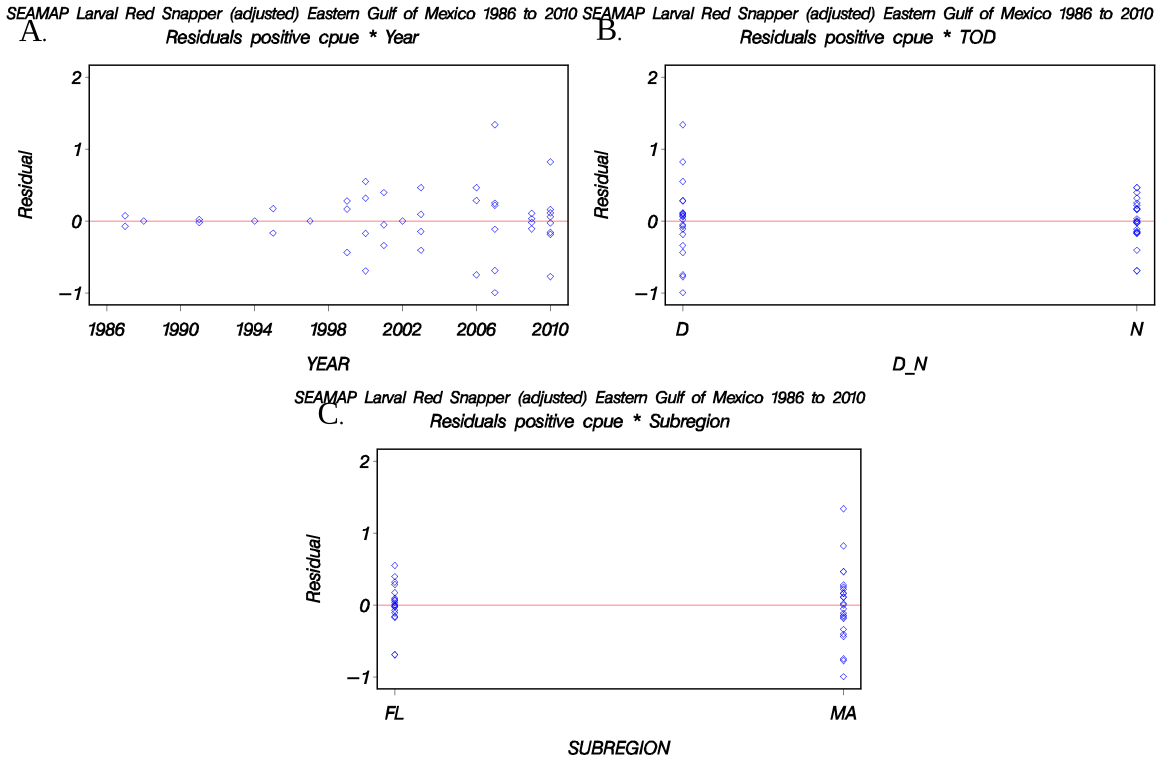


Figure 23. Diagnostic plots for lognormal component of the larval red snapper adjusted to 10.5 days old SEAMAP Fall Plankton Survey (Eastern Gulf of Mexico) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by time of day and **C.** the Chi-Square residuals by subregion.

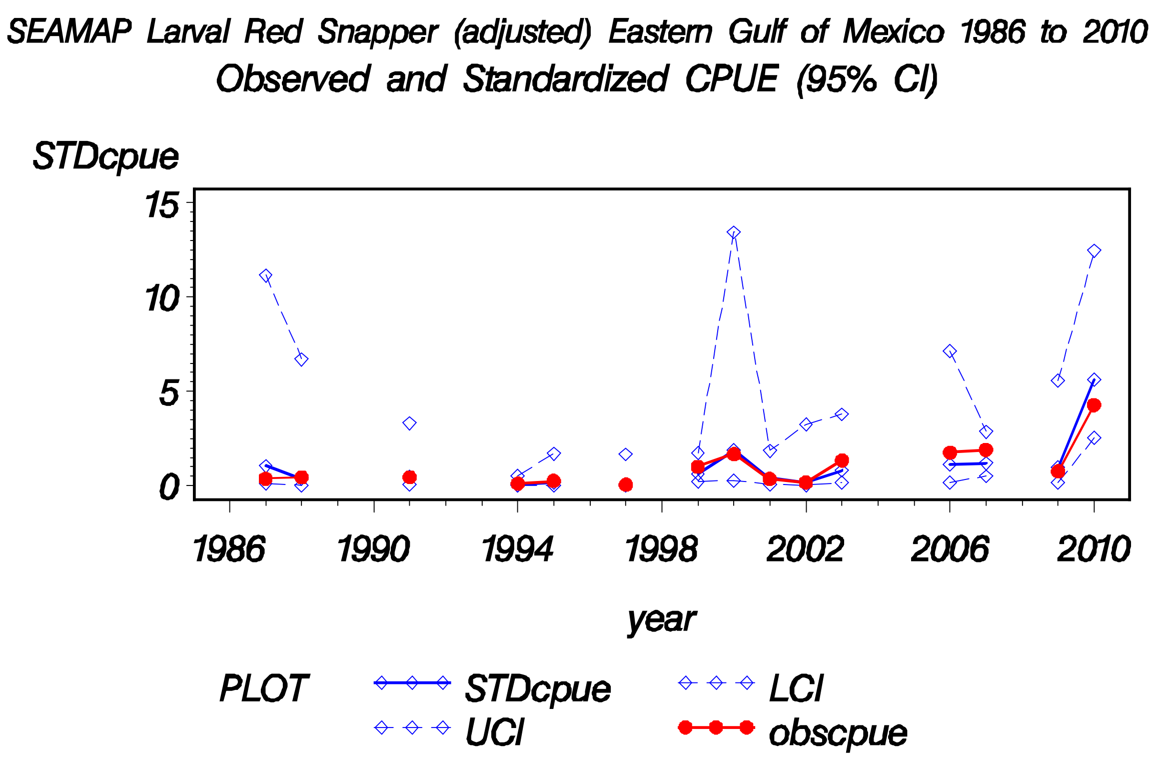


Figure 24. Annual index of abundance for larval red snapper adjusted to 10.5 days old (Eastern Gulf of Mexico) from the SEAMAP Fall Plankton Survey from 1986 – 2010.

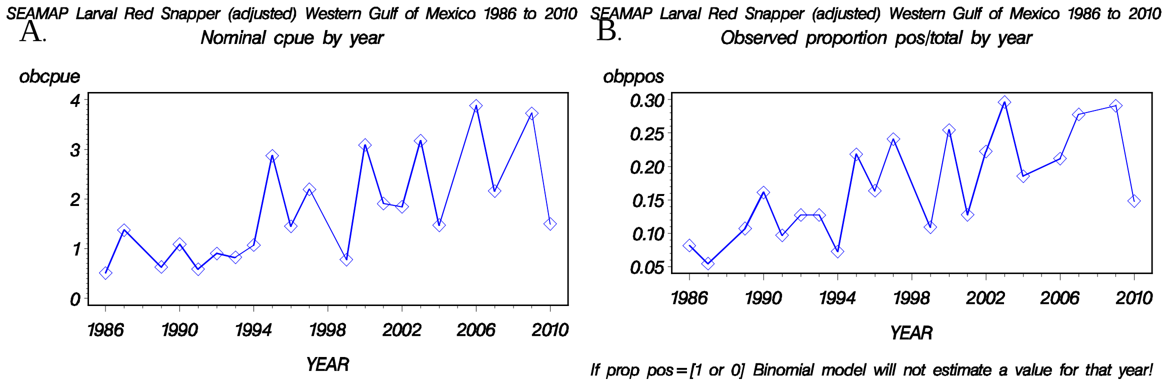


Figure 25. Annual trends for larval red snapper adjusted to 10.5 days old captured during the SEAMAP Fall Plankton Survey (Western Gulf of Mexico) from 1986 to 2010 in **A.** nominal CPUE and **B.** proportion of positive stations.

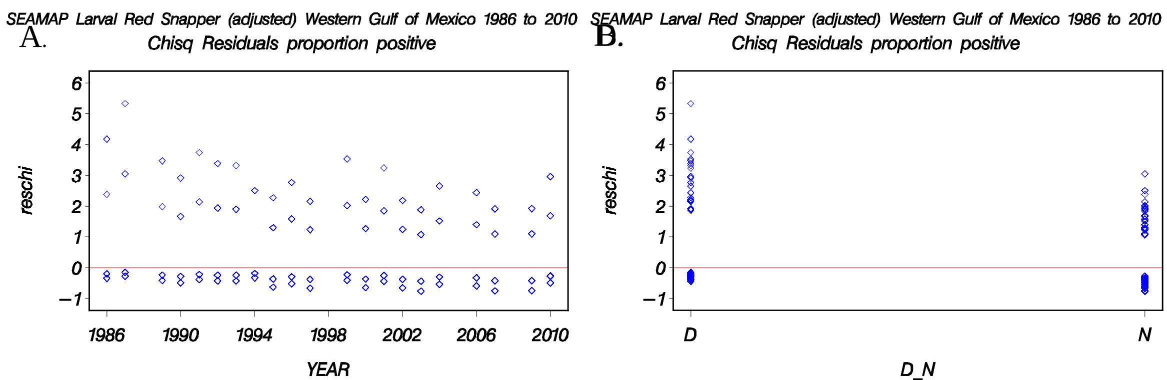


Figure 26. Diagnostic plots for binomial component of the larval red snapper adjusted to 10.5 days old SEAMAP Fall Plankton Survey (Western Gulf of Mexico) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by time of day and **C.** the Chi-Square residuals by subregion.

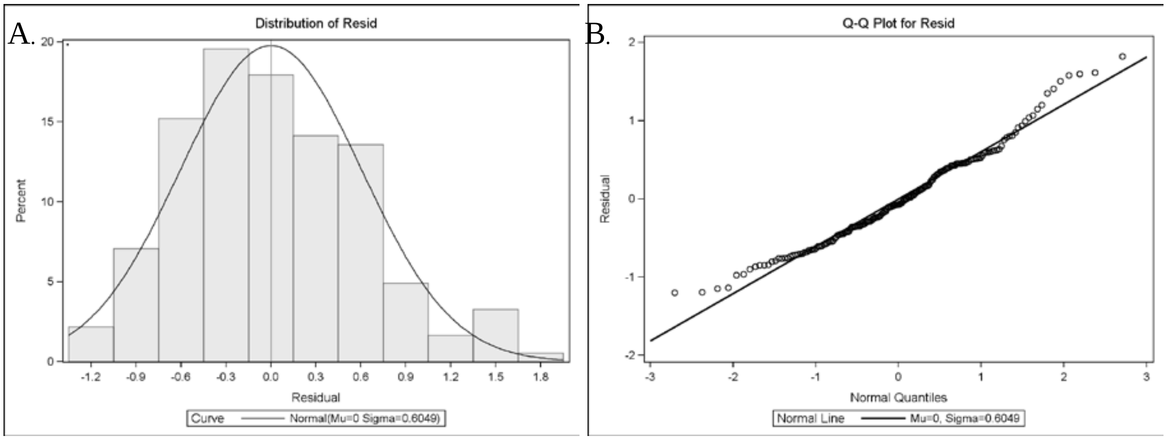


Figure 27. Diagnostic plots for lognormal component of the larval red snapper adjusted to 10.5 days old SEAMAP Fall Plankton Survey (Western Gulf of Mexico) model: **A.** the frequency distribution of log(CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

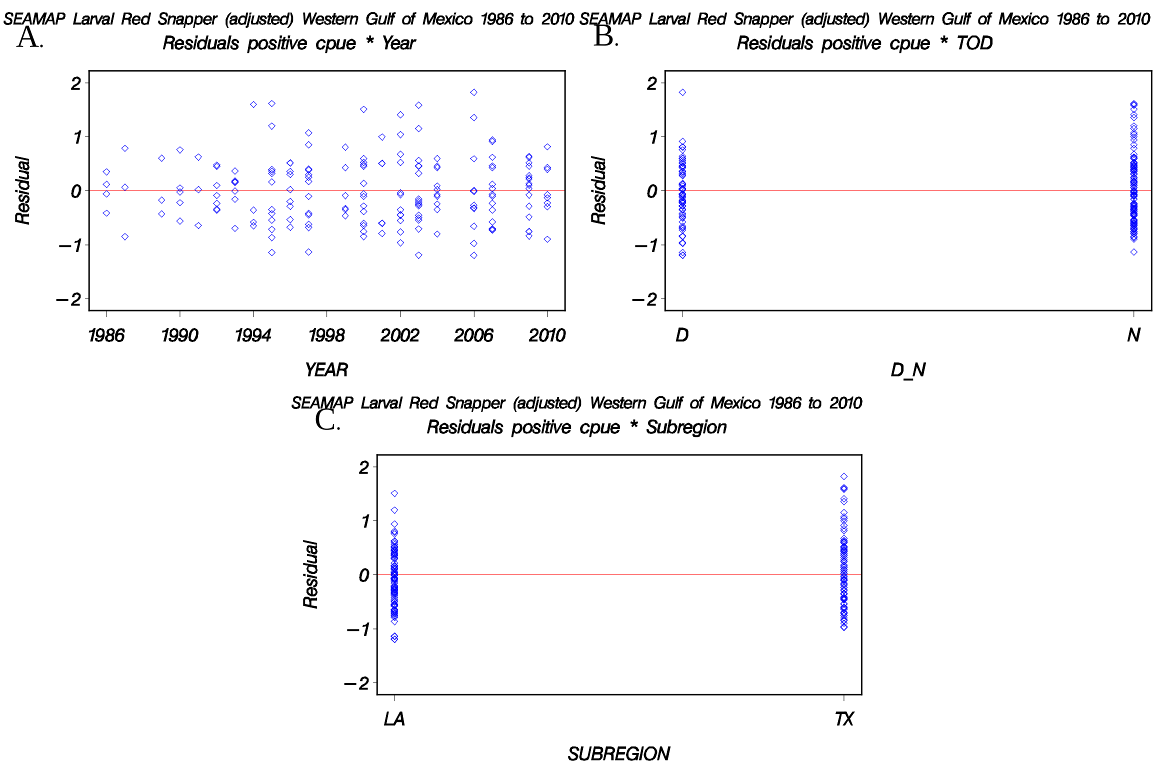


Figure 28. Diagnostic plots for lognormal component of the larval red snapper adjusted to 10.5 days old SEAMAP Fall Plankton Survey (Western Gulf of Mexico) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by time of day and **C.** the Chi-Square residuals by subregion.

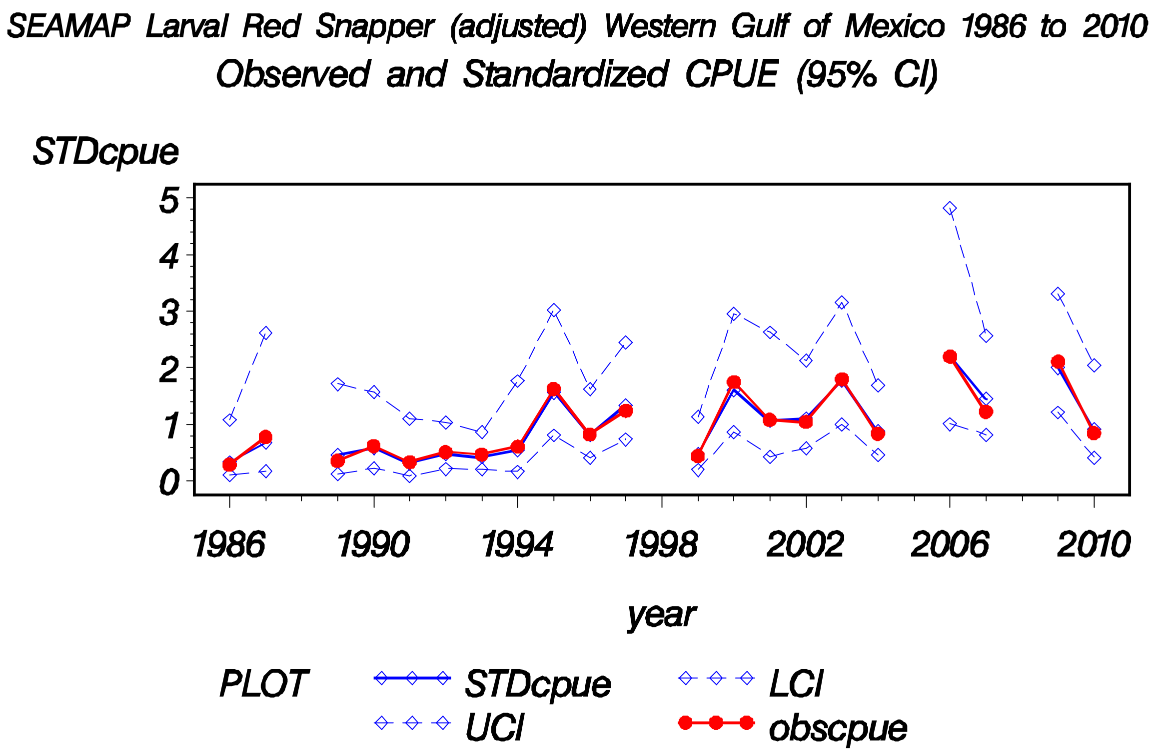


Figure 29. Annual index of abundance for larval red snapper adjusted to 10.5 days old (Western Gulf of Mexico) from the SEAMAP Fall Plankton Survey from 1986 – 2010.

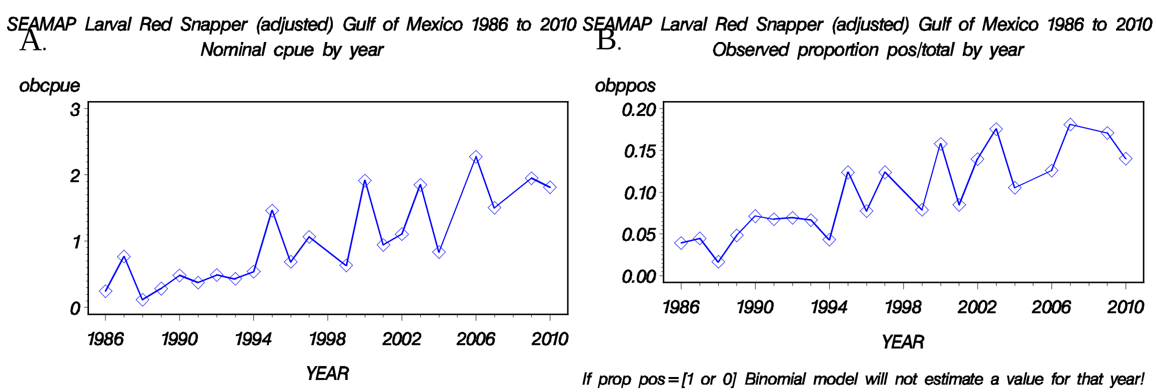


Figure 30. Annual trends for larval red snapper adjusted to 10.5 days old captured during the SEAMAP Fall Plankton Survey (Gulf of Mexico) from 1986 to 2010 in **A.** nominal CPUE and **B.** proportion of positive stations.

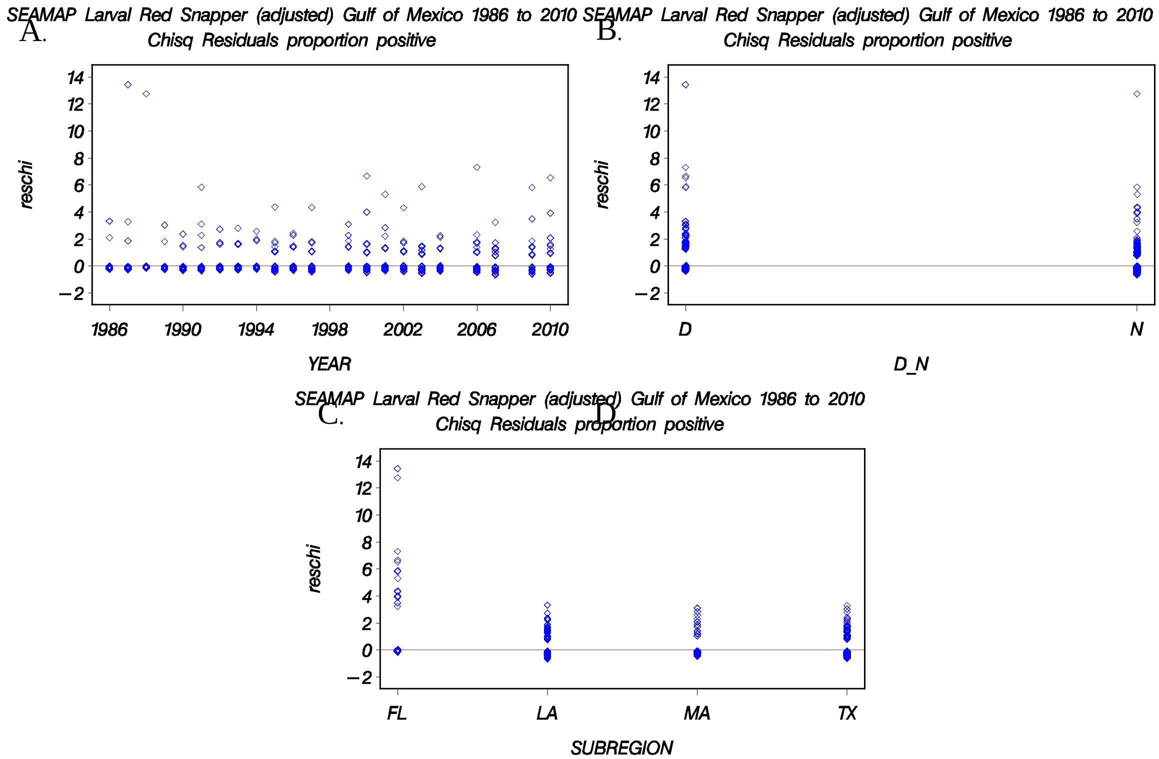


Figure 31. Diagnostic plots for binomial component of the larval red snapper adjusted to 10.5 days old SEAMAP Fall Plankton Survey (Gulf of Mexico) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by time of day and **C.** the Chi-Square residuals by subregion.

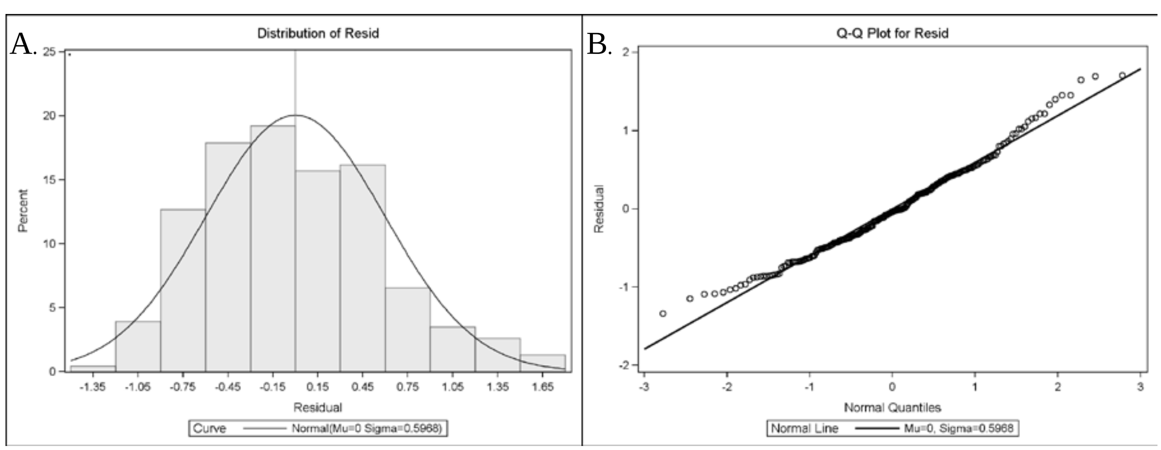


Figure 32. Diagnostic plots for lognormal component of the larval red snapper adjusted to 10.5 days old SEAMAP Fall Plankton Survey (Gulf of Mexico) model: **A.** the frequency distribution of log(CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

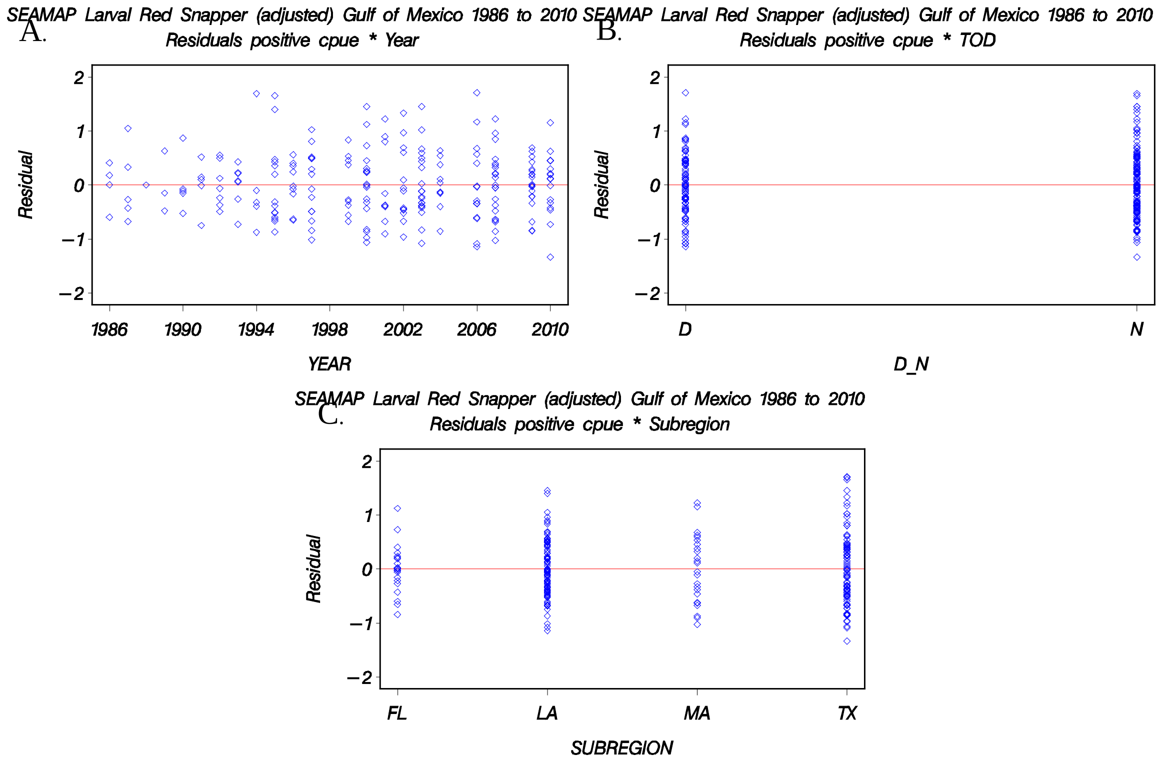


Figure 33. Diagnostic plots for lognormal component of the larval red snapper adjusted to 10.5 days old SEAMAP Fall Plankton Survey (Gulf of Mexico) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by time of day and **C.** the Chi-Square residuals by subregion.

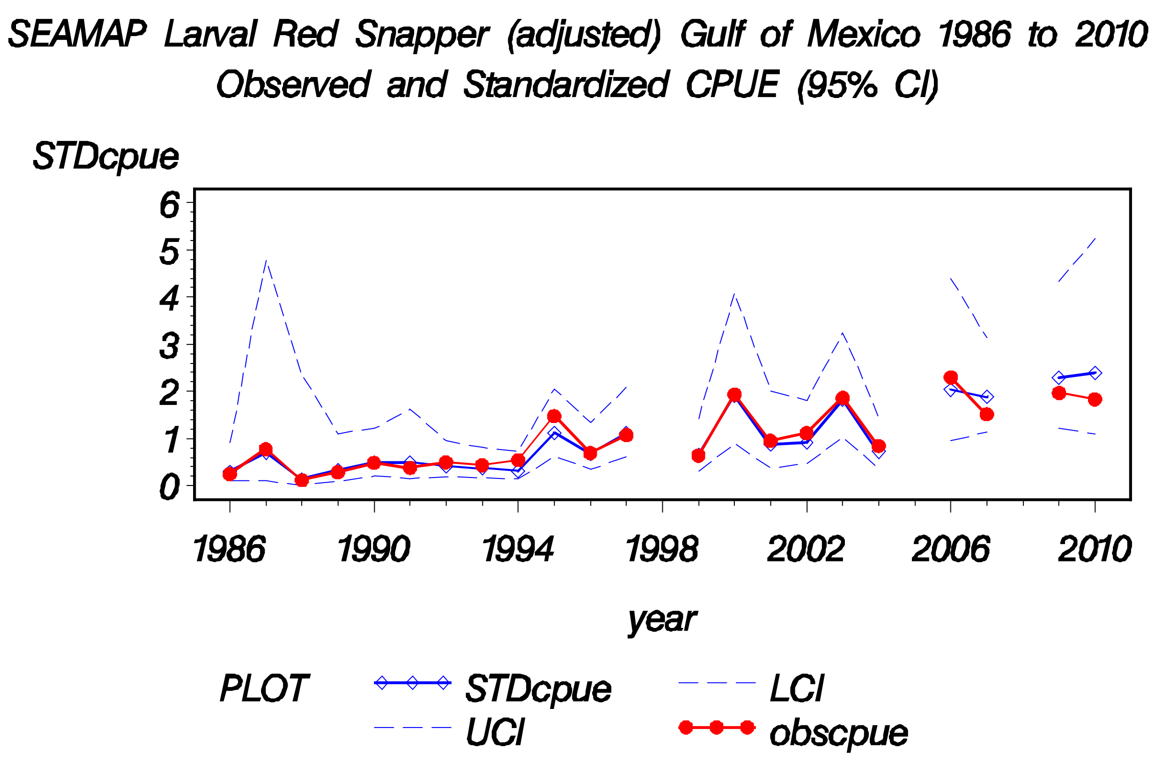
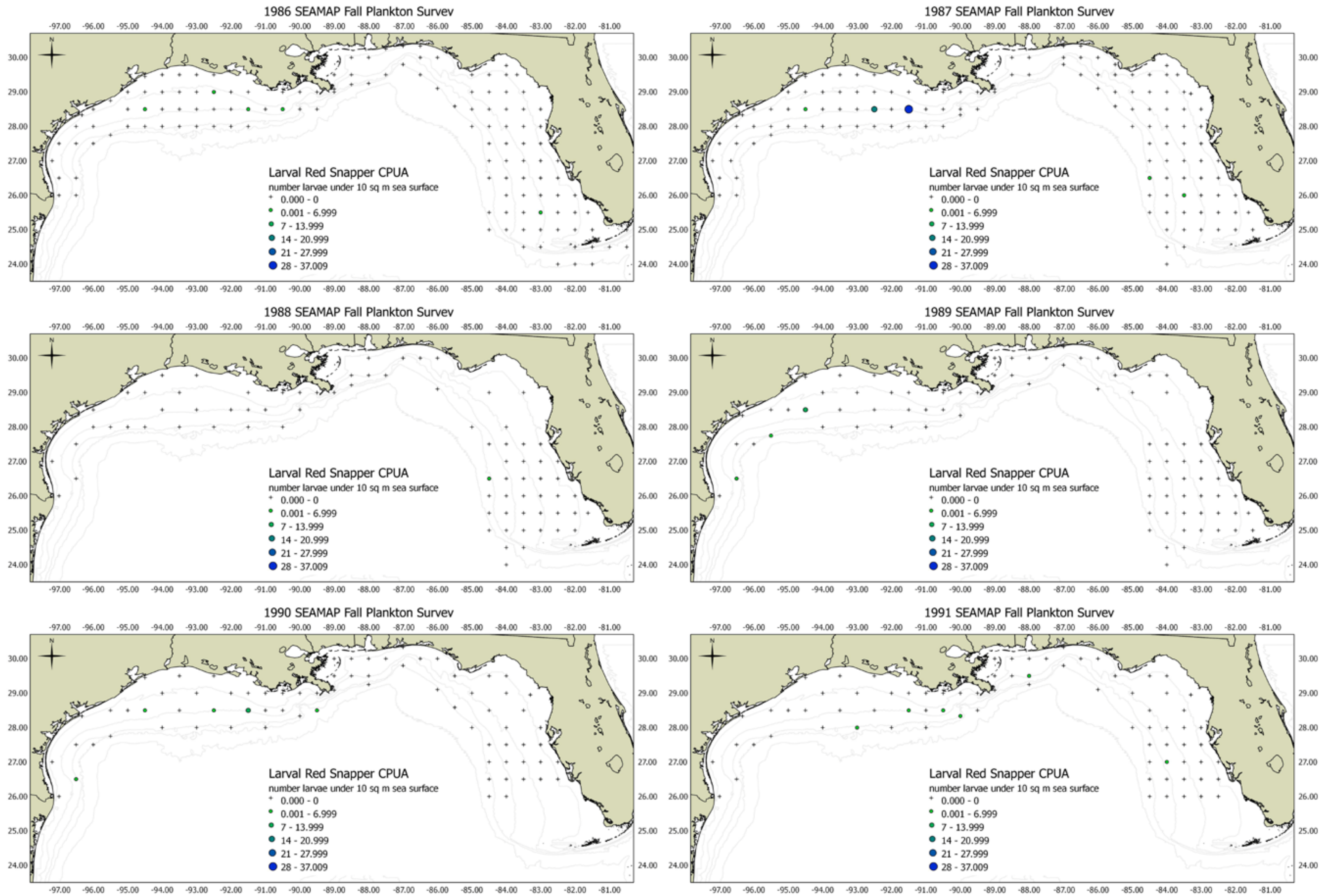
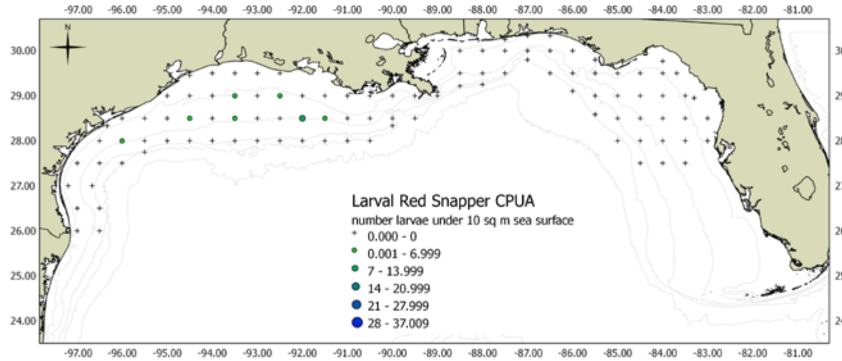


Figure 34. Annual index of abundance for larval red snapper adjusted to 10.5 days old (Gulf of Mexico) from the SEAMAP Fall Plankton Survey from 1986 – 2010.

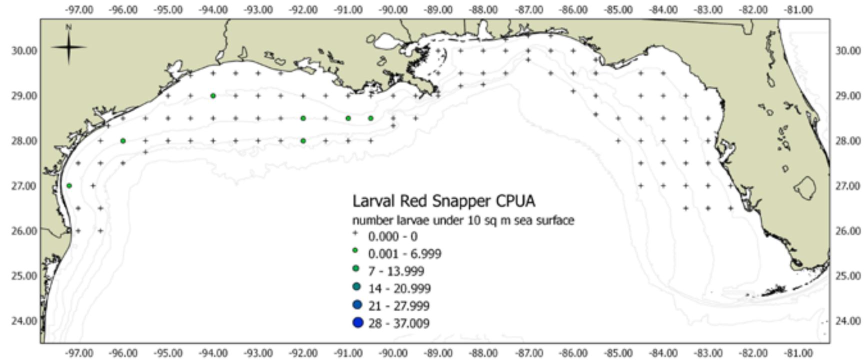
Appendix Figure 1. Annual survey effort and catch of larval red snapper from the SEAMAP Fall Plankton Survey conducted from 1986-2010.



1992 SEAMAP Fall Plankton Survey



1993 SEAMAP Fall Plankton Survey



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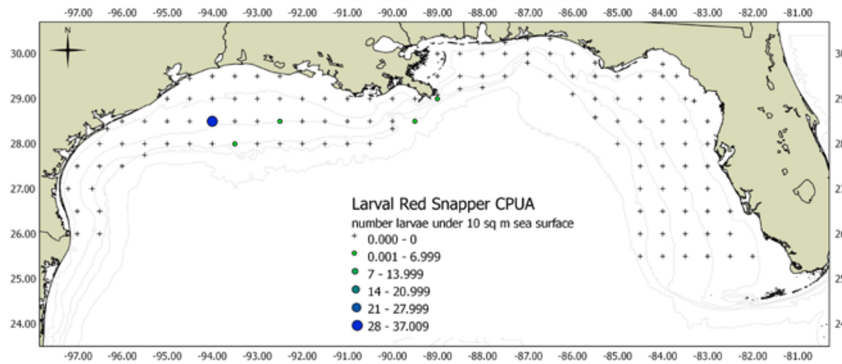
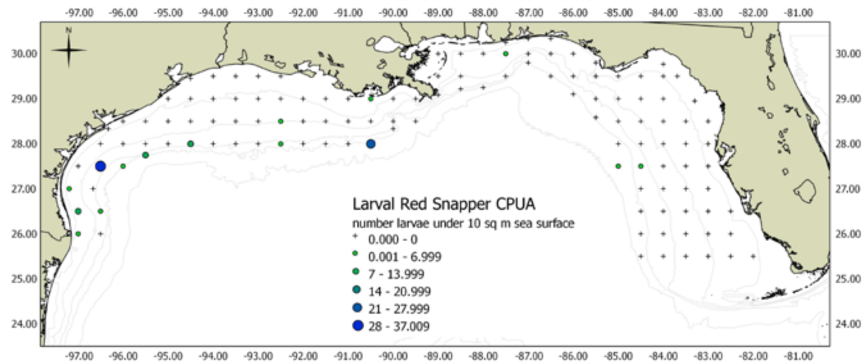


1995 SEAMAP Fall Plankton Survey



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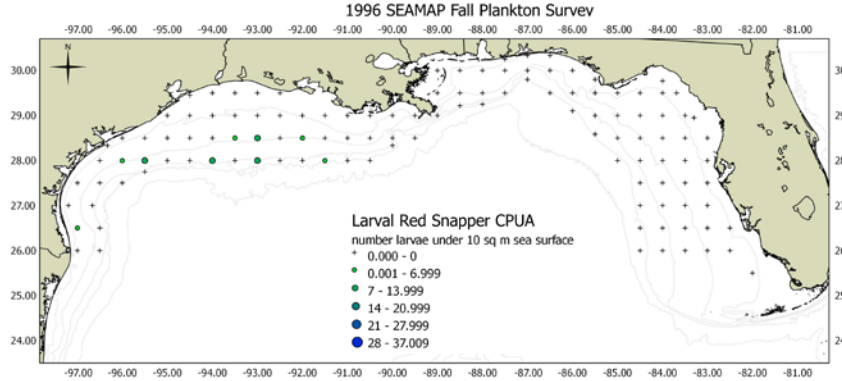
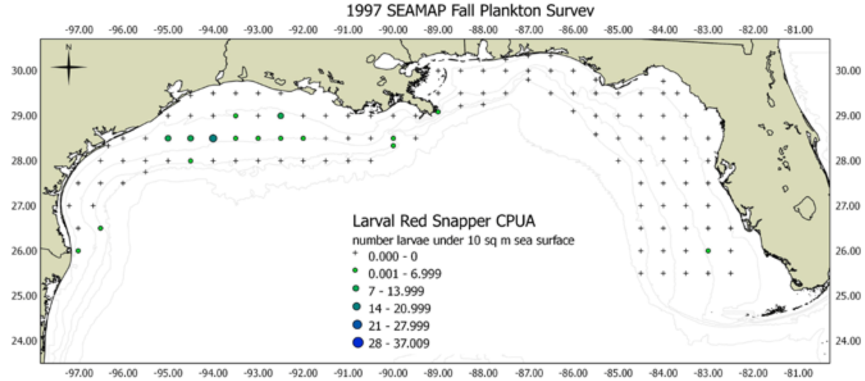
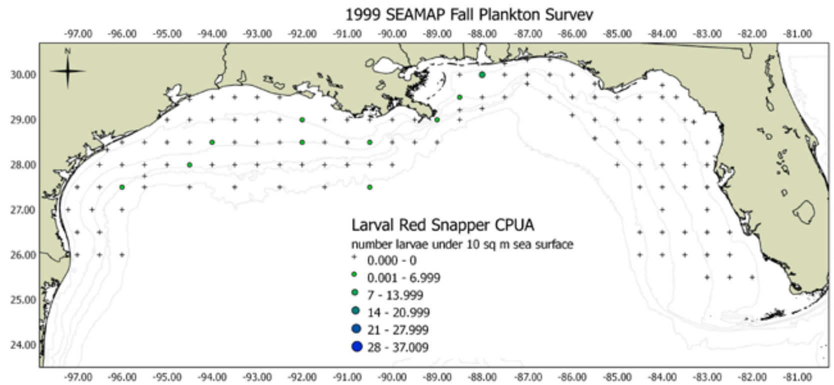
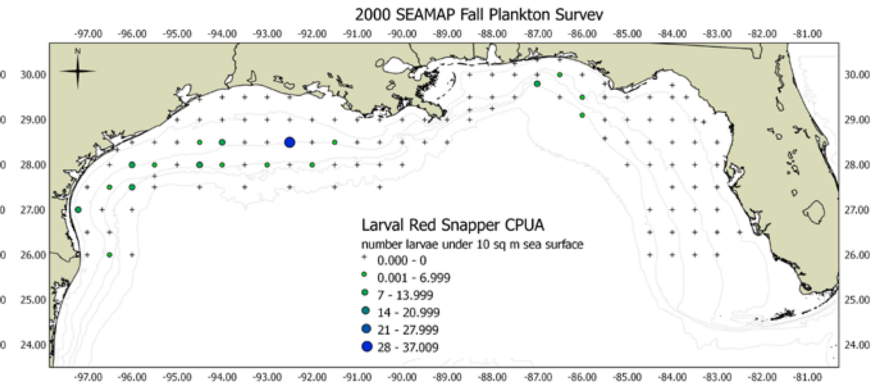


1997 SEAMAP Fall Plankton Survey




1999 SEAMAP Fall Plankton Survey
-97.00 -96.00 -95.00 -94.00 -93.00 -92.00 -91.00 -90.00 -89.00 -88.00 -87.00 -86.00 -85.00 -84.00 -83.00 -82.00 -81.00
30.00 29.00 28.00 27.00 26.00 25.00 24.00
N
Larval Red Snapper CPUA
number larvae under 10 sq m sea surface
0.000 - 0
0.001 - 6.999
7 - 13.999
14 - 20.999
21 - 27.999
28 - 37.009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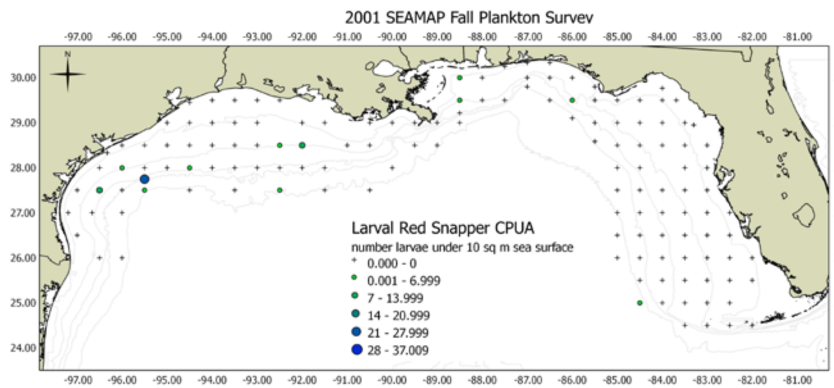
-97.00 -96.00 -95.00 -94.00 -93.00 -92.00 -91.00 -90.00 -89.00 -88.00 -87.00 -86.00 -85.00 -84.00 -83.00 -82.00 -81.00
30.00 29.00 28.00 27.00 26.00 25.00 24.00
N
Larval Red Snapper CPUA
number larvae under 10 sq m sea surface
0.000 - 0
0.001 - 6.999
7 - 13.999
14 - 20.999
21 - 27.999
28 - 37.009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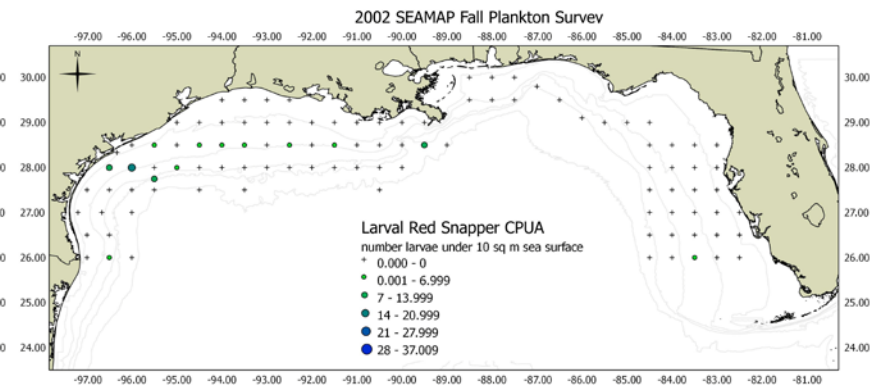
30.00 29.00 28.00 27.00 26.00 25.00 24.00
N
Larval Red Snapper CPUA
number larvae under 10 sq m sea surface
0.000 - 0
0.001 - 6.999
7 - 13.999
14 - 20.999
21 - 27.999
28 - 37.009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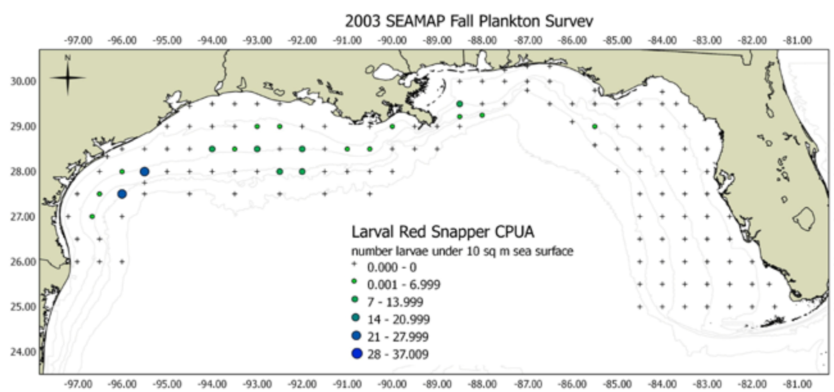
30.00 29.00 28.00 27.00 26.00 25.00 24.00
N
Larval Red Snapper CPUA
number larvae under 10 sq m sea surface
0.000 - 0
0.001 - 6.999
7 - 13.999
14 - 20.999
21 - 27.999
28 - 37.009


2003 SEAMAP Fall Plankton Survey
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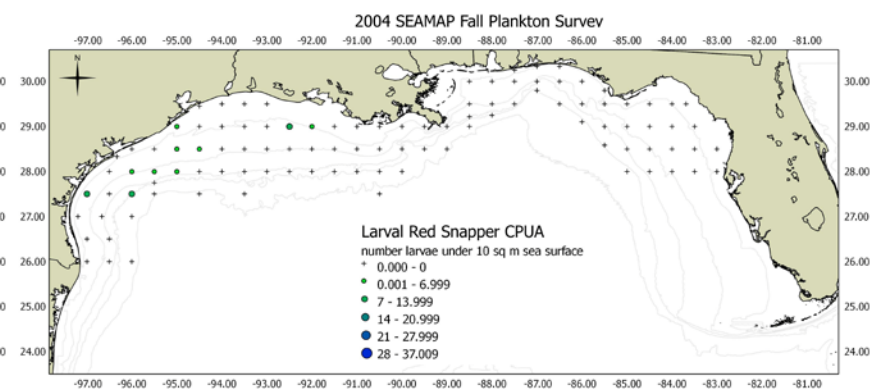
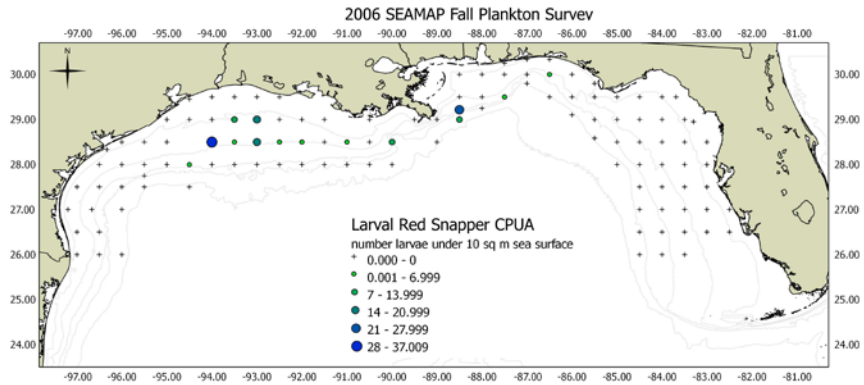
30.00 29.00 28.00 27.00 26.00 25.00 24.00
N
Larval Red Snapper CPUA
number larvae under 10 sq m sea surface
0.000 - 0
0.001 - 6.999
7 - 13.999
14 - 20.999
21 - 27.999
28 - 37.009


2004 SEAMAP Fall Plankton Survey
-97.00 -96.00 -95.00 -94.00 -93.00 -92.00 -91.00 -90.00 -89.00 -88.00 -87.00 -86.00 -85.00 -84.00 -83.00 -82.00 -81.00
30.00 29.00 28.00 27.00 26.00 25.00 24.00
N
Larval Red Snapper CPUA
number larvae under 10 sq m sea surface
0.000 - 0
0.001 - 6.999
7 - 13.999
14 - 20.999
21 - 27.999
28 - 37.009


2006 SEAMAP Fall Plankton Survey
Larval Red Snapper CPUA
number larvae under 10 sq m sea surface
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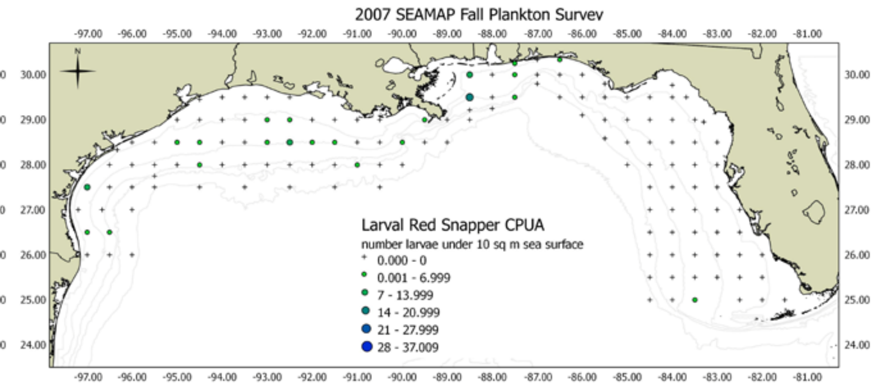
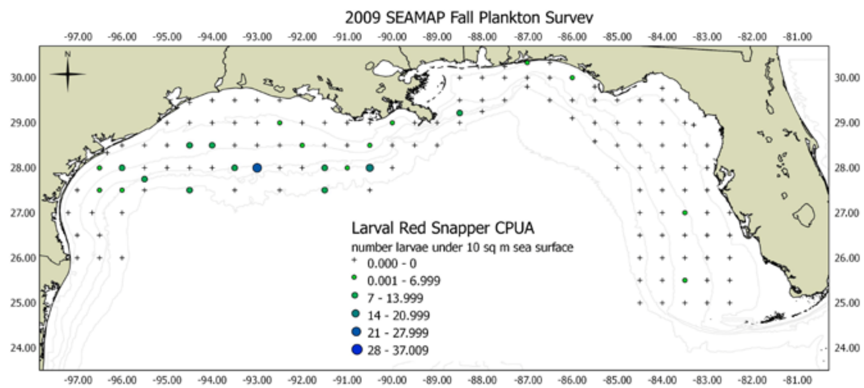
0.001 - 6.999
7 - 13.999
14 - 20.999
21 - 27.999
28 - 37.009


2007 SEAMAP Fall Plankton Survey
Larval Red Snapper CPUA
number larvae under 10 sq m sea surface
0.000 - 0
0.001 - 6.999
7 - 13.999
14 - 20.999
21 - 27.999
28 - 37.009


2009 SEAMAP Fall Plankton Survey
Larval Red Snapper CPUA
number larvae under 10 sq m sea surface
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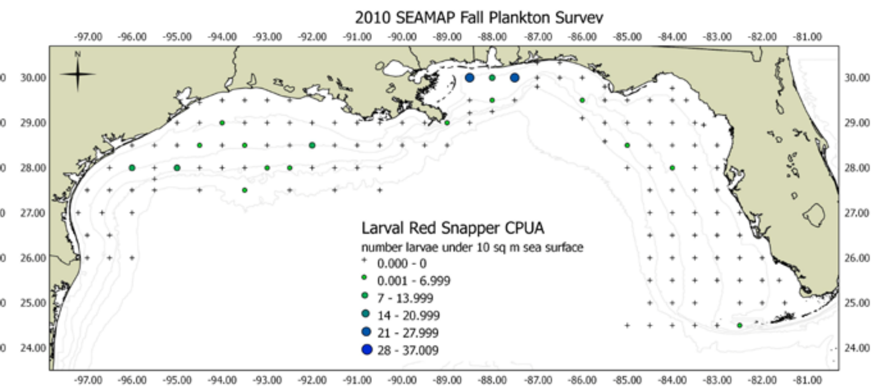
0.001 - 6.999
7 - 13.999
14 - 20.999
21 - 27.999
28 - 37.009


2010 SEAMAP Fall Plankton Survey
Larval Red Snapper CPUA
number larvae under 10 sq m sea surface
0.000 - 0
0.001 - 6.999
7 - 13.999
14 - 20.999
21 - 27.999
28 - 37.009

Addendum to SEDAR31-DW27

During the Data Workshop, questions were raised about expanding the maximum length of larvae used in the index from 6.25 mm to 9.25 mm based on new capture data (Addendum Figure1). Once it was determined expanding the size range to 9.25 mm would be acceptable, a new estimate for Z (-0.1503) was calculated in order to backcalculate to 10.5 day old larvae for the age adjusted indices. The methodology to estimate Z, along with the calculation of annual abundance indices were the same as those outlined in the main section of this document.

For the EGOM abundance index of larval red snapper, the nominal CPUE and number of stations with a positive catch are presented in Addendum Figure2.Year, time of day and subregion were retained in both the binomial and lognormal submodels. Addendum Table 1 summarizes backward selection procedure used to select the final set of variables used in the submodels and their significance. The AIC for the binomial and lognormal submodels were 6337.5 and 69.7, respectively. The diagnostic plots for the binomial and lognormal submodels are shown in Addendum Figures 3-5, and indicated the distribution of the residuals is approximately normal. Annual abundance indices are presented in Addendum Table 2 and Addendum Figure6.

For the WGOM abundance index of larval red snapper, the nominal CPUE and number of stations with a positive catch are presented in Addendum Figure7.Year and time of day were retained in the binomial submodel, while year, time of day, subregion and depth were retained in the lognormal submodel. Addendum Table 3 summarizes backward selection procedure used to select the final set of variables used in the submodels and their significance. The AIC for the binomial and lognormal submodels were 5277.0 and 395.2, respectively. The diagnostic plots for the binomial and lognormal submodels are shown in Addendum Figures 8-10, and indicated the distribution of the residuals is approximately normal. Annual abundance indices are presented in Addendum Table 4 and Addendum Figure 11.

For the EGOM abundance index of larval red snapper adjusted to 10.5 days old, the nominal CPUE and number of stations with a positive catch are presented in Addendum Figure12.Year, time of day and subregion were retained in both the binomial and lognormal submodels. Addendum Table5 summarizes backward selection procedure used to select the final set of variables used in the submodels and their significance. The AIC for the binomial and lognormal submodels were 6337.5 and 97.8, respectively. The diagnostic plots for the binomial and lognormal submodels are shown in Addendum Figures 13-15, and indicated the distribution of the residuals is approximately normal. Annual abundance indices are presented in Addendum Table6 and Addendum Figure16.

For the WGOM abundance index of larval red snapper adjusted to 10.5 days old, the nominal CPUE and number of stations with a positive catch are presented in Addendum Figure17.Year and time of day were retained in the binomial submodel, while year, time of day and subregion were retained in the lognormal submodel. Addendum Table7 summarizes backward selection procedure used to select the final set of variables used in the submodels and their significance. The AIC for the binomial and lognormal submodels were 5277.0 and 542.8, respectively. The diagnostic plots for the binomial and lognormal submodels are shown in Addendum Figures 18-20, and indicated the distribution of the residuals is approximately normal. Annual abundance indices are presented in Addendum Table8 and Addendum Figure 21.

Addendum Table 1. Summary of backward selection procedure for building delta-lognormal submodels for larval red snapper (Eastern Gulf of Mexico) index of relative abundance from 1986 to 2010.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 6611.3)*						*Lognormal Submodel Type 3 Tests (AIC 79.9)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	15	292	31.20	2.02	0.0082	0.0142	15	30	2.15	0.0362
Time of Day	1	338	5.49	5.49	0.0191	0.0197	1	30	7.20	0.0118
Subregion	1	344	78.76	78.76	<.0001	<.0001	1	30	12.79	0.0012
Start Water Depth	1	301	2.69	2.69	0.1011	0.1022	1	30	0.11	0.7480
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 6337.5)*						*Lognormal Submodel Type 3 Tests (AIC 69.7)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	15	292	31.55	2.04	0.0074	0.0129	15	31	2.31	0.0238
Time of Day	1	383	6.29	6.29	0.0122	0.0126	1	31	8.39	0.0069
Subregion	1	393	78.89	78.89	<.0001	<.0001	1	31	13.12	0.0010
Start Water Depth	dropped						dropped			

Addendum Table 2.Indices of larval red snapper(Eastern Gulf of Mexico) abundance developed using the delta-lognormal model for 1986-2010. The nominal frequency of occurrence, the number of samples (*N*), the DL Index (number under 10 sea surface), the DL indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

Survey Year	Frequency	*N*	DL Index	Scaled Index	CV	LCL	UCL
1986	0.00000	53					
1987	0.03509	57	0.55404	1.11737	1.69336	0.10915	11.4387
1988	0.03125	32	0.20328	0.40996	2.30699	0.02712	6.1981
1989	0.00000	34					
1990	0.00000	39					
1991	0.04651	43	0.27312	0.55082	1.09328	0.09350	3.2450
1992	0.00000	46					
1993	0.00000	50					
1994	0.01639	61	0.02893	0.05835	1.54497	0.00641	0.5314
1995	0.03448	58	0.08936	0.18022	1.48759	0.02077	1.5638
1996	0.00000	61					
1997	0.03390	59	0.08289	0.16718	1.40309	0.02076	1.3465
1998							
1999	0.05085	59	0.27696	0.55858	0.54105	0.20275	1.5389
2000	0.06780	59	0.71804	1.44814	1.21982	0.21457	9.7737
2001	0.05085	59	0.23388	0.47169	0.81286	0.11351	1.9602
2002	0.05128	39	0.30507	0.61525	1.88479	0.05245	7.2176
2003	0.06667	60	0.37256	0.75138	0.87881	0.16549	3.4115
2004	0.02439	41	0.06281	0.12668	3.35949	0.00533	3.0088
2005							
2006	0.05085	59	0.63212	1.27484	1.12673	0.20851	7.7945
2007	0.09677	62	0.70044	1.41265	0.42790	0.62211	3.2077
2008							
2009	0.06452	62	0.70475	1.42132	0.97907	0.27577	7.3255
2010	0.15000	60	2.69517	5.43558	0.37034	2.65372	11.1336

Addendum Table 3. Summary of backward selection procedure for building delta-lognormal submodels for larval red snapper (Western Gulf of Mexico) index of relative abundance from 1986 to 2010.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 5295.2)*						*Lognormal Submodel Type 3 Tests (AIC 395.2)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	20	342	37.39	1.80	0.0105	0.0191	20	174	1.97	0.0108
Time of Day	1	906	41.42	41.42	<.0001	<.0001	1	174	8.74	0.0035
Subregion	1	928	0.02	0.02	0.8997	0.8997	1	174	4.87	0.0286
Start Water Depth	1	604	1.20	1.20	0.2738	0.2743	1	174	7.77	0.0059
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 5292.1)*						*Lognormal Submodel Type 3 Tests (AIC 395.2)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	20	343	37.56	1.81	0.0100	0.0184	20	174	1.97	0.0108
Time of Day	1	907	41.93	41.93	<.0001	<.0001	1	174	8.74	0.0035
Subregion				dropped			1	174	4.87	0.0286
Start Water Depth	1	606	1.18	1.18	0.2770	0.2774	1	174	7.77	0.0059
Model Run #3	*Binomial Submodel Type 3 Tests (AIC 5277.0)*						*Lognormal Submodel Type 3 Tests (AIC 395.2)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	20	343	37.85	1.83	0.0092	0.0171	20	174	1.97	0.0108
Time of Day	1	910	42.05	42.05	<.0001	<.0001	1	174	8.74	0.0035
Subregion				dropped			1	174	4.87	0.0286
Start Water Depth				dropped			1	174	7.77	0.0059

Addendum Table 4.Indices of larval red snapper(Western Gulf of Mexico) abundance developed using the delta-lognormal model for 1986-2010. The nominal frequency of occurrence, the number of samples (*N*), the DL Index (number under 10 sea surface), the DL indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

Survey Year	Frequency	*N*	DL Index	Scaled Index	CV	LCL	UCL
1986	0.08163	49	0.41194	0.30644	0.69375	0.08748	1.07352
1987	0.07273	55	0.93597	0.69628	0.72324	0.19028	2.54790
1988	0.00000	28					
1989	0.14286	28	1.00225	0.74558	0.56119	0.26182	2.12317
1990	0.19355	31	1.04224	0.77533	0.45162	0.32755	1.83529
1991	0.09677	31	0.42313	0.31477	0.64536	0.09671	1.02451
1992	0.12727	55	0.46732	0.34764	0.40470	0.15954	0.75755
1993	0.12727	55	0.59689	0.44403	0.40540	0.20351	0.96881
1994	0.07273	55	0.77256	0.57471	0.68643	0.16587	1.99132
1995	0.23636	55	1.97387	1.46838	0.32028	0.78598	2.74324
1996	0.16364	55	1.13856	0.84698	0.36414	0.41820	1.71540
1997	0.25926	54	1.78293	1.32633	0.28068	0.76466	2.30059
1998							
1999	0.14545	55	0.58713	0.43677	0.37358	0.21199	0.89991
2000	0.27273	55	2.07779	1.54568	0.28960	0.87624	2.72658
2001	0.14894	47	1.46726	1.09151	0.43197	0.47726	2.49632
2002	0.22222	54	1.56686	1.16560	0.32278	0.62101	2.18775
2003	0.29630	54	2.66137	1.97981	0.30765	1.08497	3.61269
2004	0.22222	54	1.18318	0.88017	0.27971	0.50837	1.52392
2005							
2006	0.23077	52	2.82910	2.10459	0.36863	1.03069	4.29742
2007	0.29630	54	1.91550	1.42496	0.27163	0.83571	2.42967
2008							
2009	0.30909	55	2.37374	1.76584	0.25078	1.07757	2.89374
2010	0.14815	54	1.01973	0.75858	0.44878	0.32206	1.78679

Addendum Table 5. Summary of backward selection procedure for building delta-lognormal submodels for larval red snapper adjusted to 10.5 days old (Eastern Gulf of Mexico) index of relative abundance from 1986 to 2010.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 6611.3)*						*Lognormal Submodel Type 3 Tests (AIC 107.2)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	15	292	31.20	2.02	0.0082	0.0142	15	30	2.06	0.0449
Time of Day	1	338	5.49	5.49	0.0191	0.0197	1	30	6.56	0.0157
Subregion	1	344	78.76	78.76	<.0001	<.0001	1	30	9.92	0.0037
Start Water Depth	1	301	2.69	2.69	0.1011	0.1022	1	30	0.03	0.8579
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 6337.5)*						*Lognormal Submodel Type 3 Tests (AIC 97.8)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	15	292	31.55	2.04	0.0074	0.0129	15	31	2.14	0.0358
Time of Day	1	383	6.29	6.29	0.0122	0.0126	1	31	7.48	0.0102
Subregion	1	393	78.89	78.89	<.0001	<.0001	1	31	10.21	0.0032
Start Water Depth				dropped				dropped		

Addendum Table6.Indices of larval red snapper adjusted to 10.5 days old(Eastern Gulf of Mexico) abundance developed using the delta-lognormal model for 1986-2010. The nominal frequency of occurrence, the number of samples (*N*), the DL Index (number under 10 sea surface), the DL indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

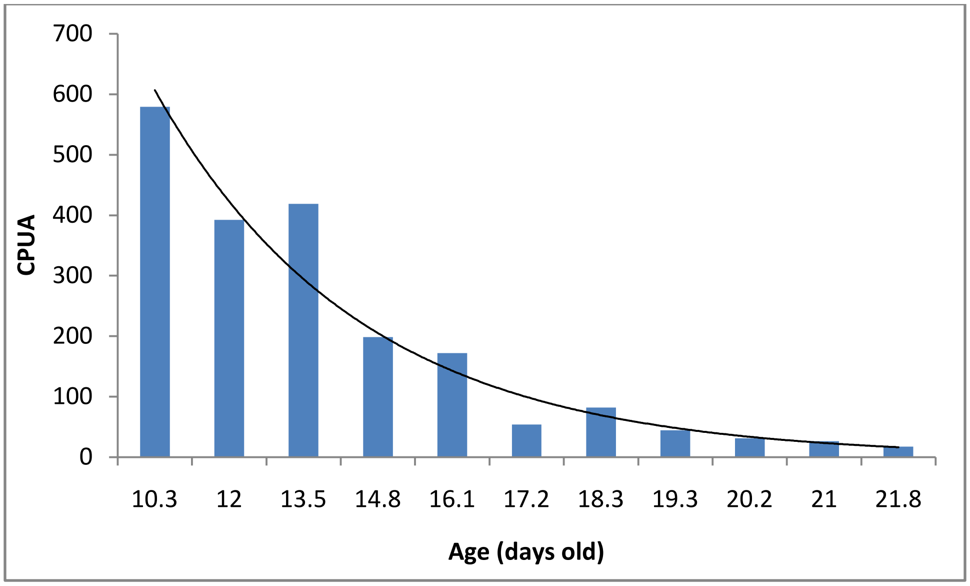
Survey Year	Frequency	*N*	DL Index	Scaled Index	CV	LCL	UCL
1986	0.00000	53					
1987	0.03509	57	1.14858	0.88541	1.70530	0.08572	9.1456
1988	0.03125	32	0.29702	0.22897	2.27316	0.01542	3.3988
1989	0.00000	34					
1990	0.00000	39					
1991	0.04651	43	0.43144	0.33259	1.11801	0.05492	2.0141
1992	0.00000	46					
1993	0.00000	50					
1994	0.01639	61	0.02137	0.01647	1.79408	0.00149	0.1815
1995	0.03448	58	0.12360	0.09528	1.44442	0.01140	0.7963
1996	0.00000	61					
1997	0.03390	59	0.17743	0.13678	1.26321	0.01940	0.9645
1998							
1999	0.05085	59	0.60273	0.46463	0.60857	0.15120	1.4277
2000	0.06780	59	2.07754	1.60151	1.23251	0.23423	10.9499
2001	0.05085	59	0.34035	0.26237	0.84837	0.06017	1.1441
2002	0.05128	39	0.85282	0.65741	1.84050	0.05776	7.4829
2003	0.06667	60	0.68647	0.52917	0.89907	0.11352	2.4668
2004	0.02439	41	0.31219	0.24066	2.74620	0.01286	4.5030
2005							
2006	0.05085	59	1.54784	1.19318	1.14739	0.19081	7.4612
2007	0.09677	62	1.45214	1.11941	0.49075	0.44209	2.8345
2008							
2009	0.06452	62	1.34720	1.03851	1.00719	0.19477	5.5374
2010	0.15000	60	9.33709	7.19767	0.42434	3.18977	16.2414

Addendum Table 7. Summary of backward selection procedure for building delta-lognormal submodels for larval red snapper adjusted to 10.5 days old (Western Gulf of Mexico) index of relative abundance from 1986 to 2010.

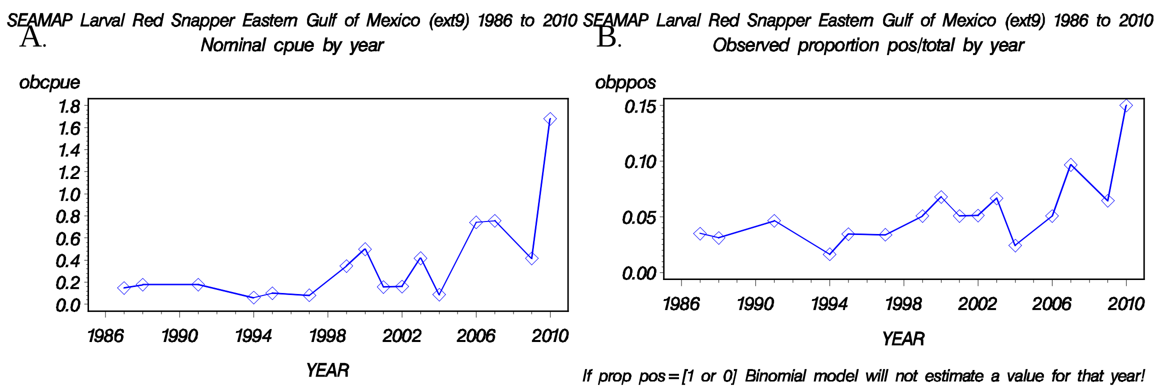
Model Run #1	*Binomial Submodel Type 3 Tests (AIC 5295.2)*						*Lognormal Submodel Type 3 Tests (AIC 542.8)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	20	342	37.39	1.80	0.0105	0.0191	20	174	1.49	0.0901
Time of Day	1	906	41.42	41.42	<.0001	<.0001	1	174	14.99	0.0002
Subregion	1	928	0.02	0.02	0.8997	0.8997	1	174	7.98	0.0053
Start Water Depth	1	604	1.20	1.20	0.2738	0.2743	1	174	0.37	0.5443
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 5292.1)*						*Lognormal Submodel Type 3 Tests (AIC 531.9)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	20	343	37.56	1.81	0.0100	0.0184	20	175	1.54	0.0721
Time of Day	1	907	41.93	41.93	<.0001	<.0001	1	175	15.36	0.0001
Subregion	dropped						1	175	8.49	0.0040
Start Water Depth	1	606	1.18	1.18	0.2770	0.2774	dropped			
Model Run #3	*Binomial Submodel Type 3 Tests (AIC 5277.0*						*Lognormal Submodel Type 3 Tests (AIC 542.8)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	20	343	37.85	1.83	0.0092	0.0171	20	175	1.54	0.0721
Time of Day	1	910	42.05	42.05	<.0001	<.0001	1	175	15.36	0.0001
Subregion	dropped						1	175	8.49	0.0040
Start Water Depth	dropped						dropped			

Addendum Table8.Indices of larval red snapper adjusted to 10.5 days old(Western Gulf of Mexico) abundance developed using the delta-lognormal model for 1986-2010. The nominal frequency of occurrence, the number of samples (*N*), the DL Index (number under 10 sea surface), the DL indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

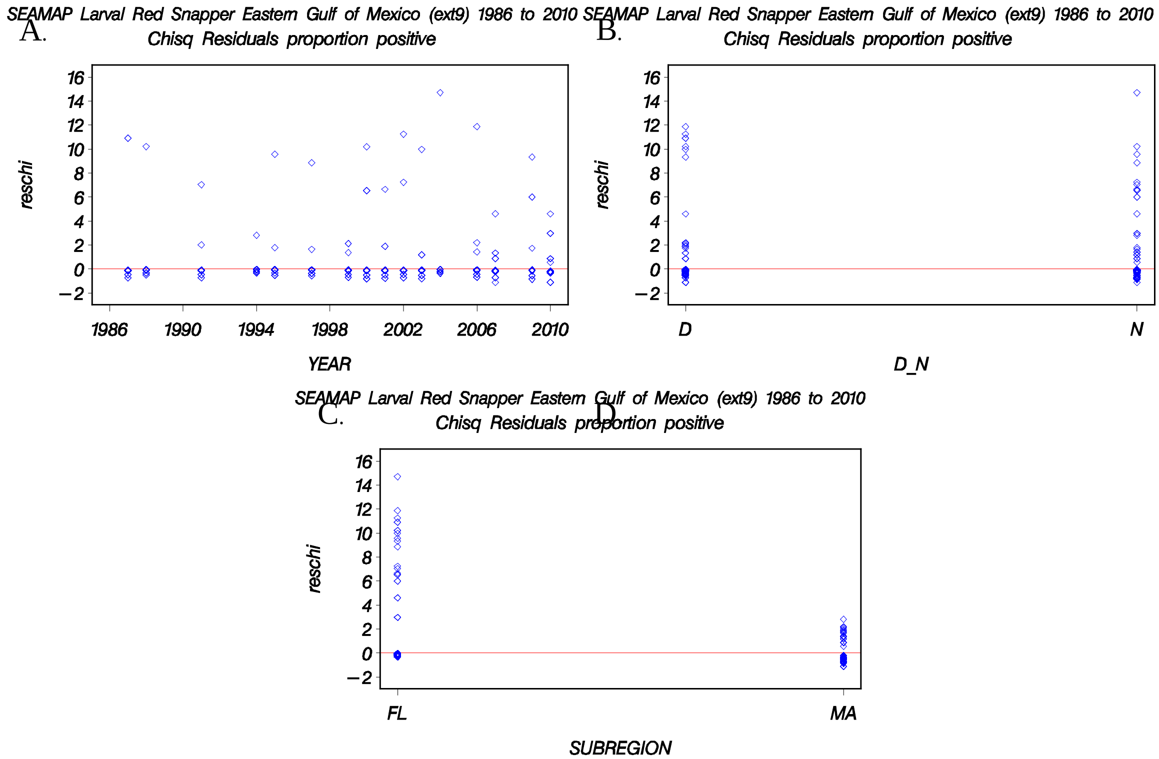
Survey Year	Frequency	*N*	DL Index	Scaled Index	CV	LCL	UCL
1986	0.08163	49	1.72024	0.51313	0.81893	0.12245	2.15016
1987	0.07273	55	2.16447	0.64563	0.67184	0.19048	2.18833
1988	0.00000	28					
1989	0.14286	28	3.19923	0.95429	0.75494	0.24908	3.65609
1990	0.19355	31	2.13106	0.63567	0.53839	0.23175	1.74360
1991	0.09677	31	0.54755	0.16333	0.76633	0.04194	0.63598
1992	0.12727	55	0.94156	0.28085	0.42395	0.12455	0.63331
1993	0.12727	55	1.23128	0.36727	0.47201	0.14978	0.90062
1994	0.07273	55	0.95695	0.28544	0.65262	0.08672	0.93952
1995	0.23636	55	3.84496	1.14690	0.34376	0.58781	2.23774
1996	0.16364	55	2.19804	0.65564	0.40881	0.29868	1.43922
1997	0.25926	54	4.13821	1.23437	0.32949	0.64952	2.34583
1998							
1999	0.14545	55	1.89683	0.56580	0.43937	0.24420	1.31093
2000	0.27273	55	6.06269	1.80842	0.33602	0.94017	3.47848
2001	0.14894	47	4.83119	1.44108	0.48318	0.57652	3.60214
2002	0.22222	54	3.48667	1.04003	0.38893	0.49097	2.20311
2003	0.29630	54	7.83030	2.33567	0.37476	1.13118	4.82272
2004	0.22222	54	3.57389	1.06604	0.36625	0.52433	2.16741
2005							
2006	0.23077	52	6.86608	2.04806	0.43882	0.88480	4.74069
2007	0.29630	54	5.32629	1.58876	0.31580	0.85753	2.94353
2008							
2009	0.30909	55	5.39710	1.60988	0.26593	0.95443	2.71545
2010	0.14815	54	2.05759	0.61375	0.43108	0.26878	1.40148



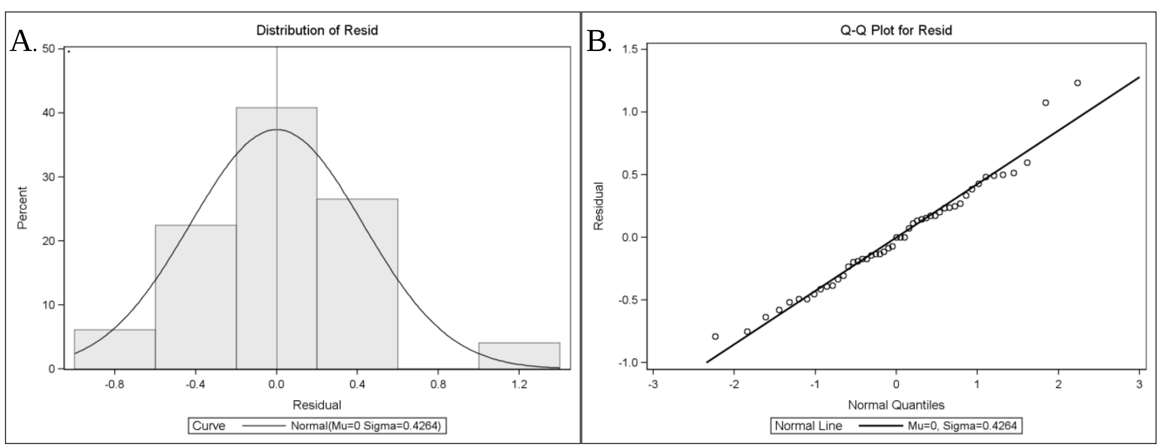
Addendum Figure 1. Age distribution (age of the size class midpoint) of the larval red snapper catch and the resulting daily loss rate curve (Z = 0.1503).



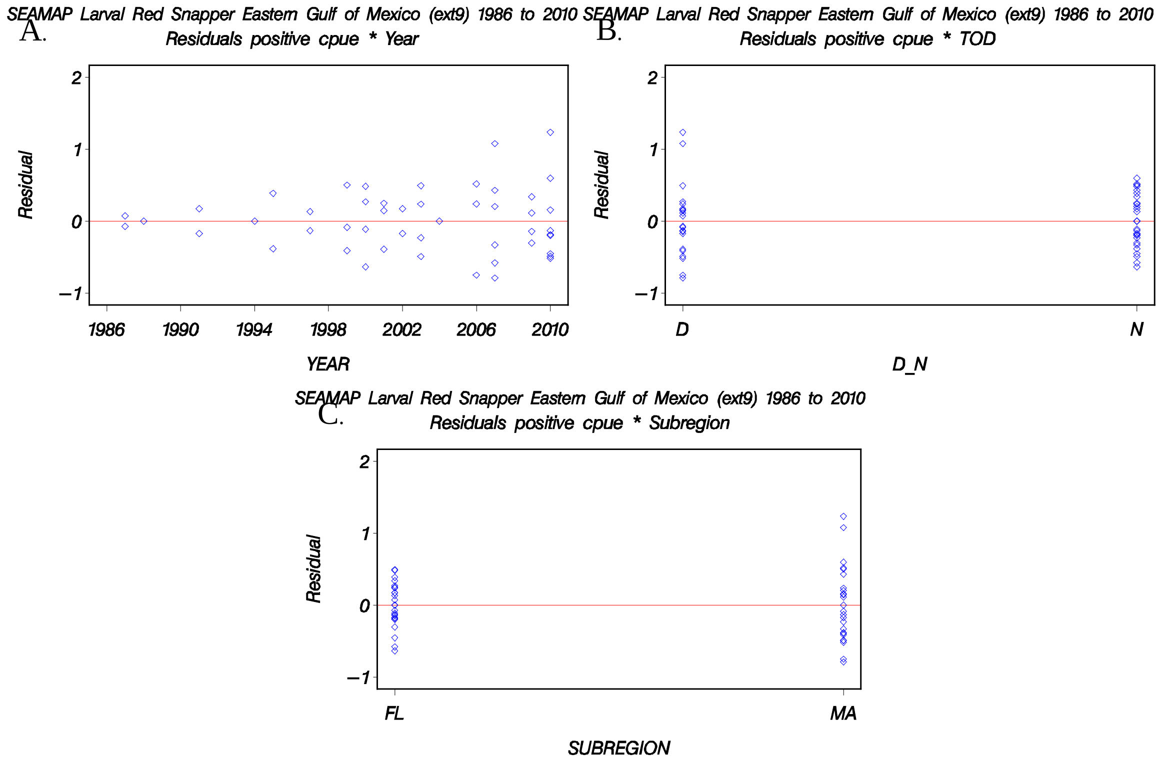
Addendum Figure 2. Annual trends for larval red snapper captured during the SEAMAP Fall Plankton Survey (Eastern Gulf of Mexico) from 1986 to 2010 in **A.** nominal CPUE and **B.** proportion of positive stations.



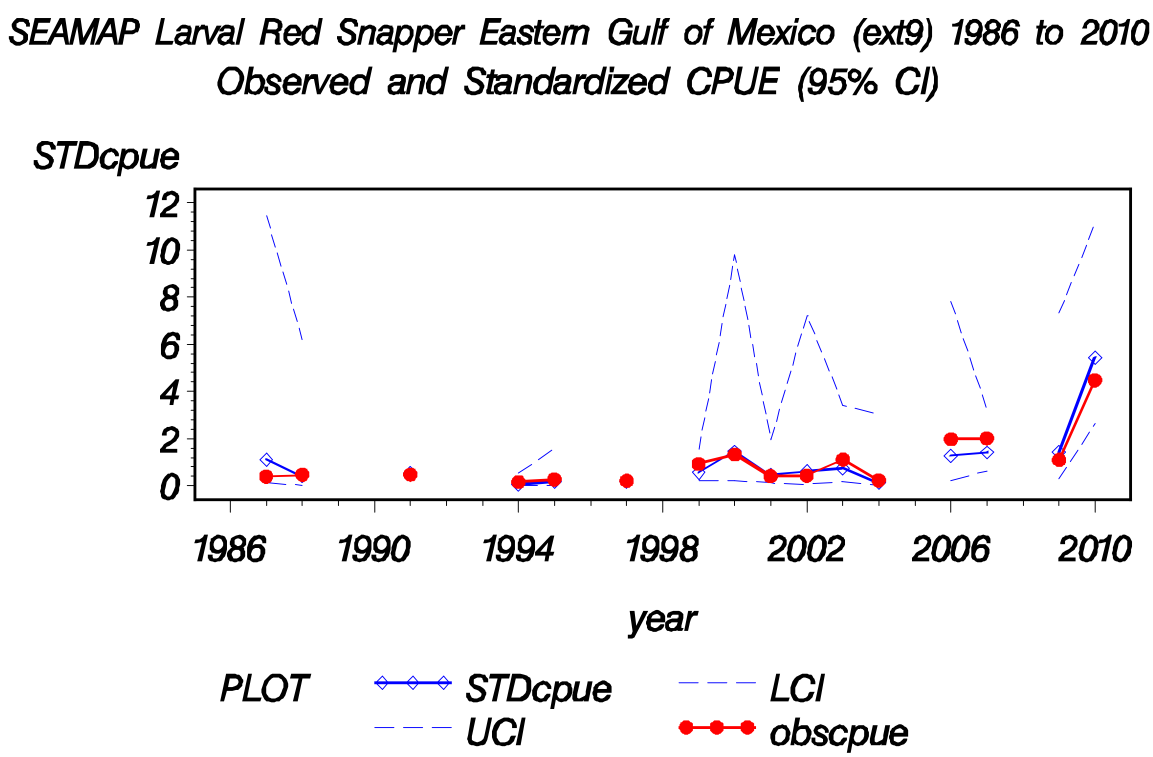
Addendum Figure 3. Diagnostic plots for binomial component of the larval red snapper SEAMAP Fall Plankton Survey (Eastern Gulf of Mexico) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by time of day and**C.** the Chi-Square residuals by subregion.



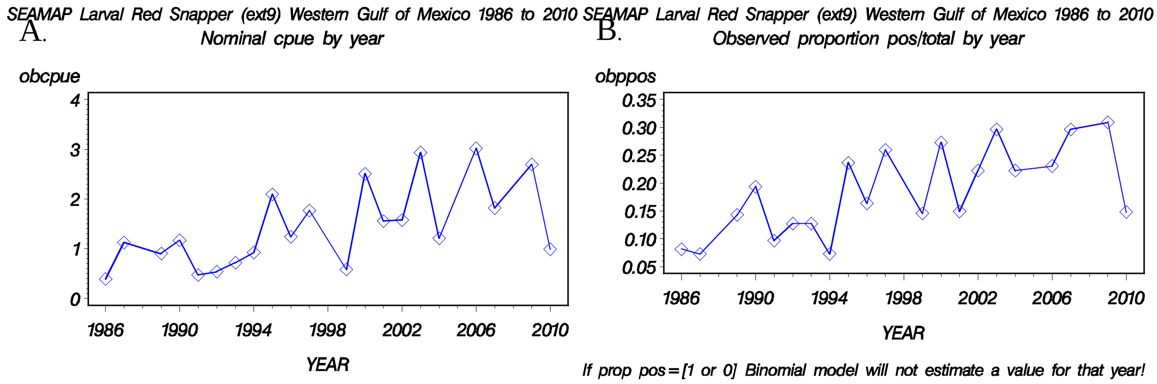
Addendum Figure 4. Diagnostic plots for lognormal component of the larval red snapper SEAMAP Fall Plankton Survey (Eastern Gulf of Mexico) model: **A.** the frequency distribution of log(CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).



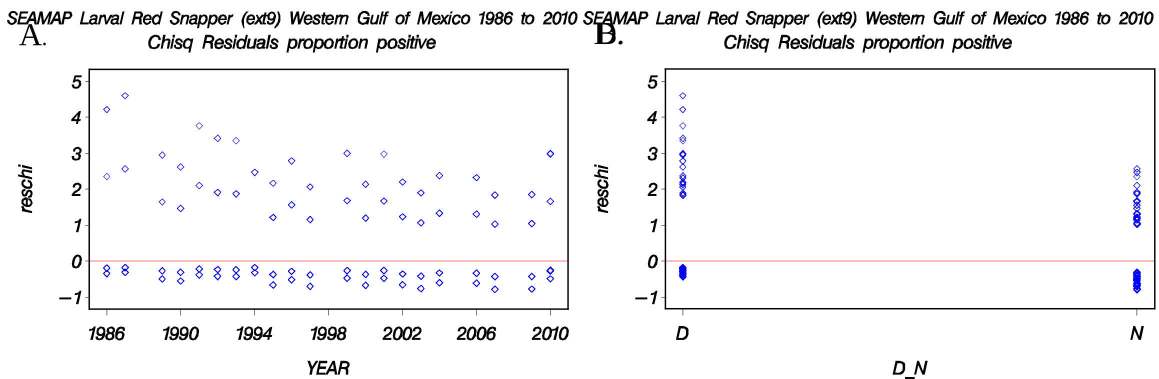
Addendum Figure 5. Diagnostic plots for lognormal component of the larval red snapper SEAMAP Fall Plankton Survey (Eastern Gulf of Mexico) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by time of day and **C.** the Chi-Square residuals by subregion.



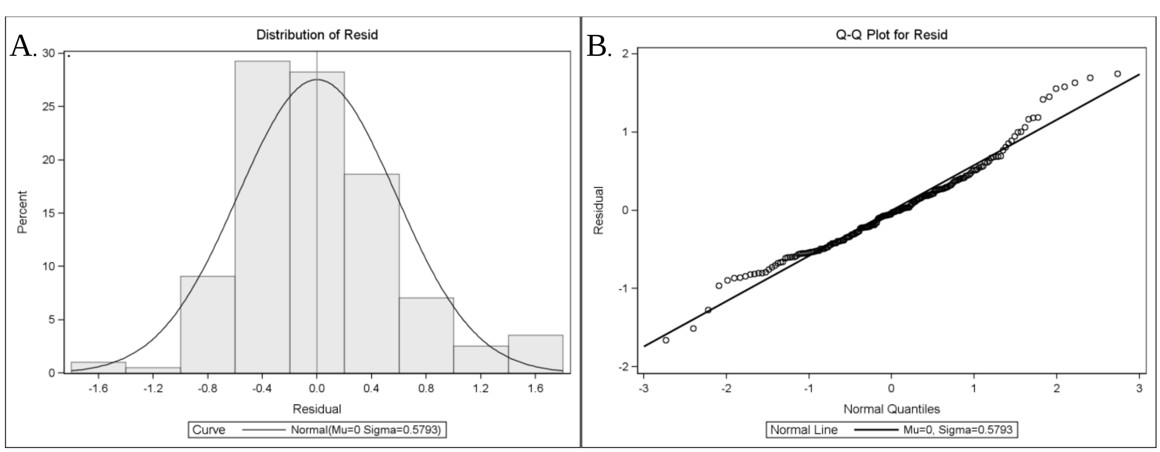
Addendum Figure 6.Annual index of abundance for larval red snapper (Eastern Gulf of Mexico) from the SEAMAP Fall Plankton Survey from 1986 – 2010.



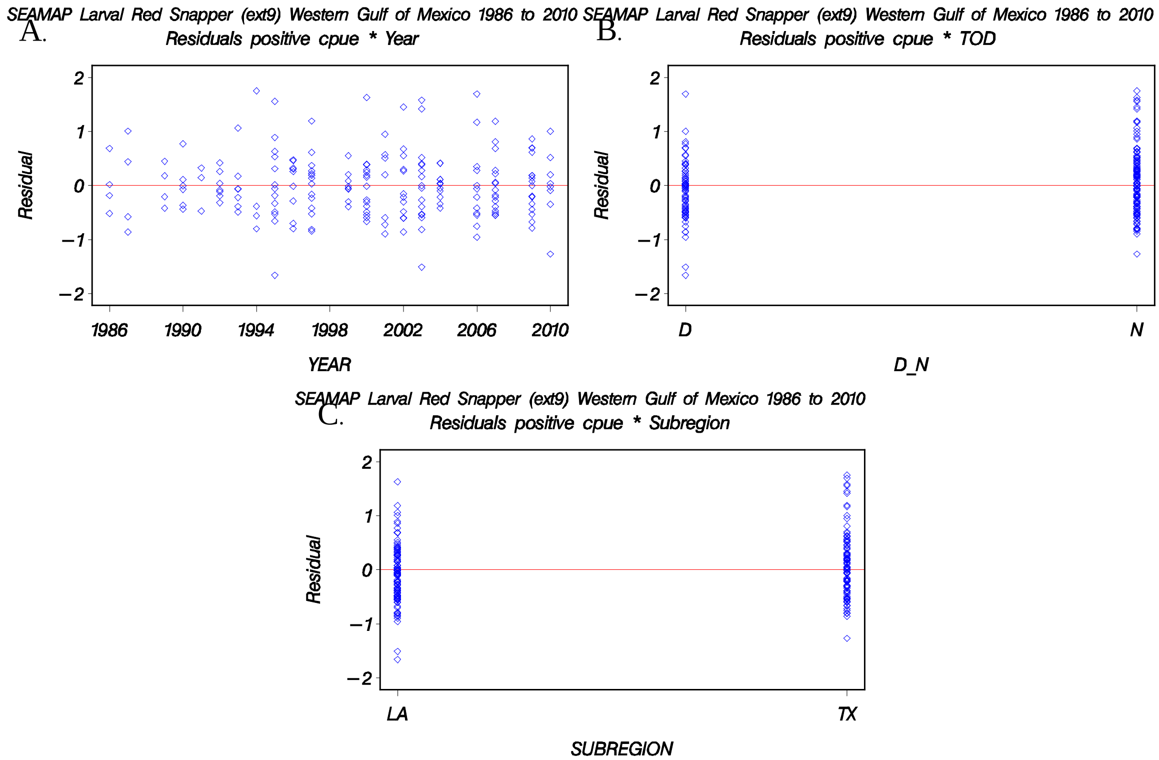
Addendum Figure 7. Annual trends for larval red snapper captured during the SEAMAP Fall Plankton Survey (Western Gulf of Mexico) from 1986 to 2010 in **A.** nominal CPUE and **B.** proportion of positive stations.



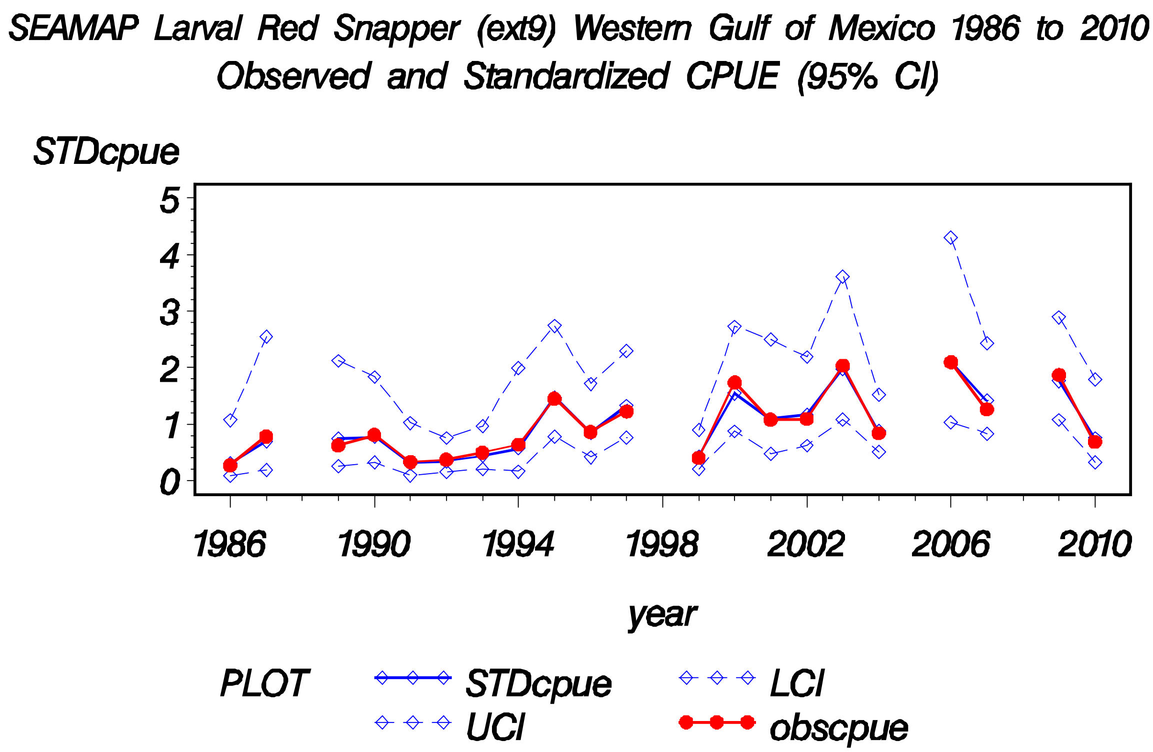
Addendum Figure 8. Diagnostic plots for binomial component of the larval red snapper SEAMAP Fall Plankton Survey (Western Gulf of Mexico) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by time of day and**C.** the Chi-Square residuals by subregion.



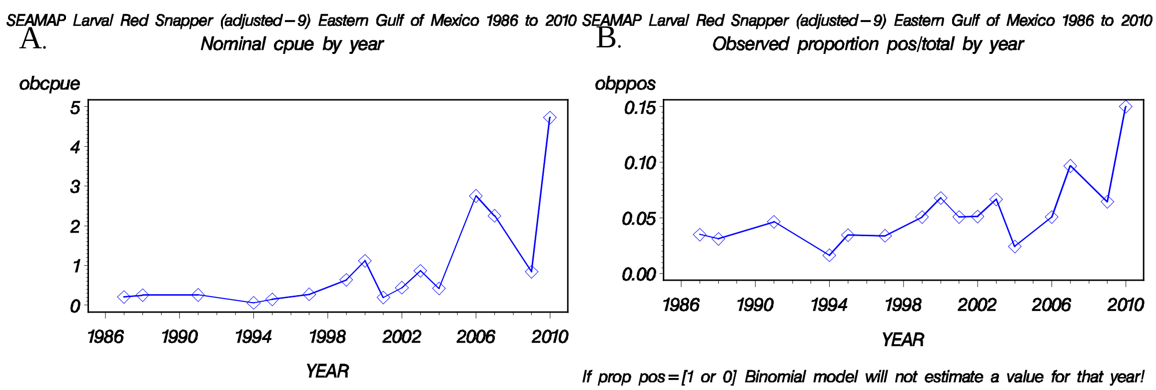
Addendum Figure 9. Diagnostic plots for lognormal component of the larval red snapper SEAMAP Fall Plankton Survey (Western Gulf of Mexico) model: **A.** the frequency distribution of log(CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).



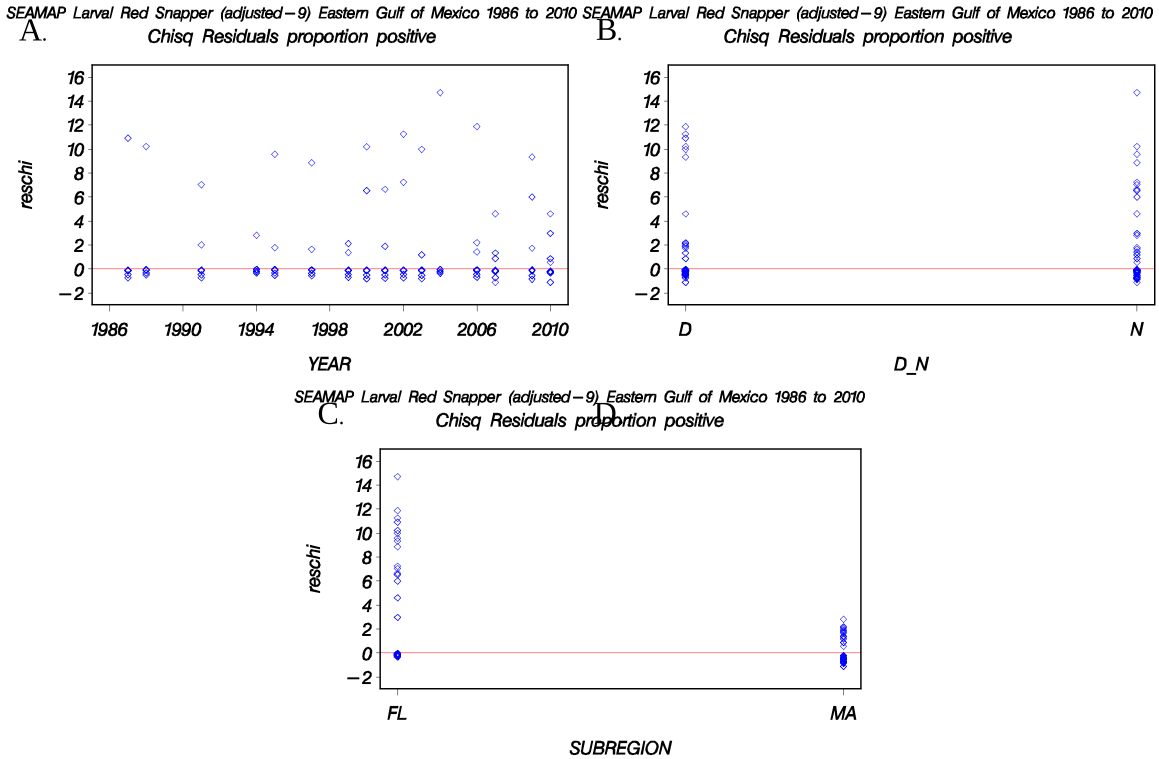
Addendum Figure 10. Diagnostic plots for lognormal component of the larval red snapper SEAMAP Fall Plankton Survey (Western Gulf of Mexico) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by time of day and **C.** the Chi-Square residuals by subregion.



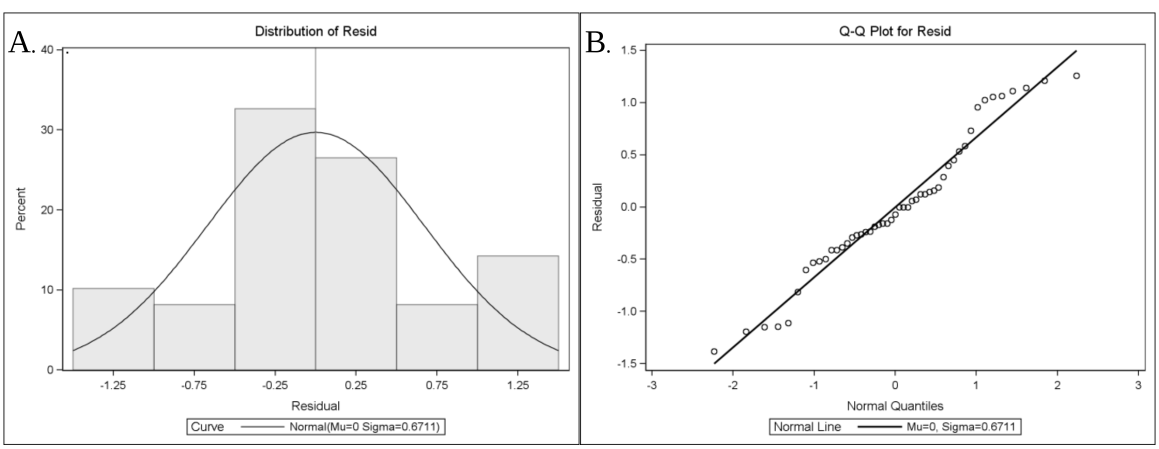
Addendum Figure 11.Annual index of abundance for larval red snapper (Western Gulf of Mexico) from the SEAMAP Fall Plankton Survey from 1986 – 2010.



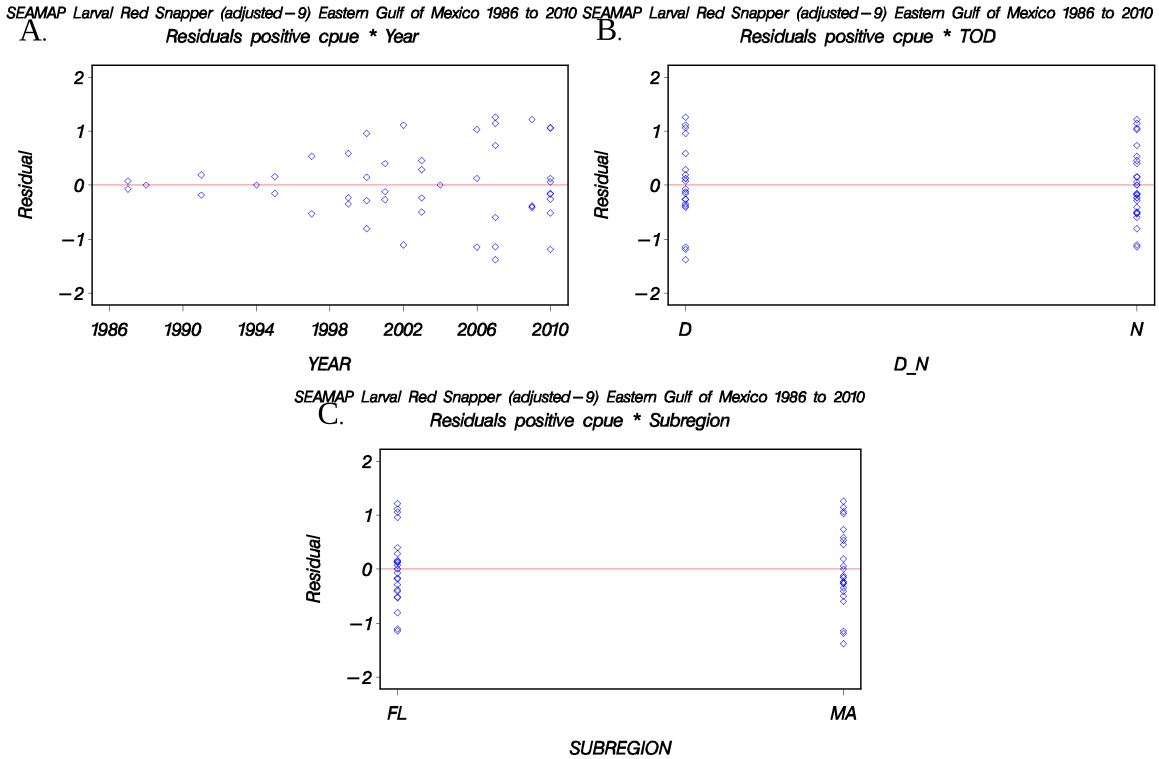
Addendum Figure 12. Annual trends for larvalred snapper adjusted to 10.5 days old captured during the SEAMAP Fall Plankton Survey (Eastern Gulf of Mexico) from 1986 to 2010 in **A.** nominal CPUE and **B.** proportion of positive stations.



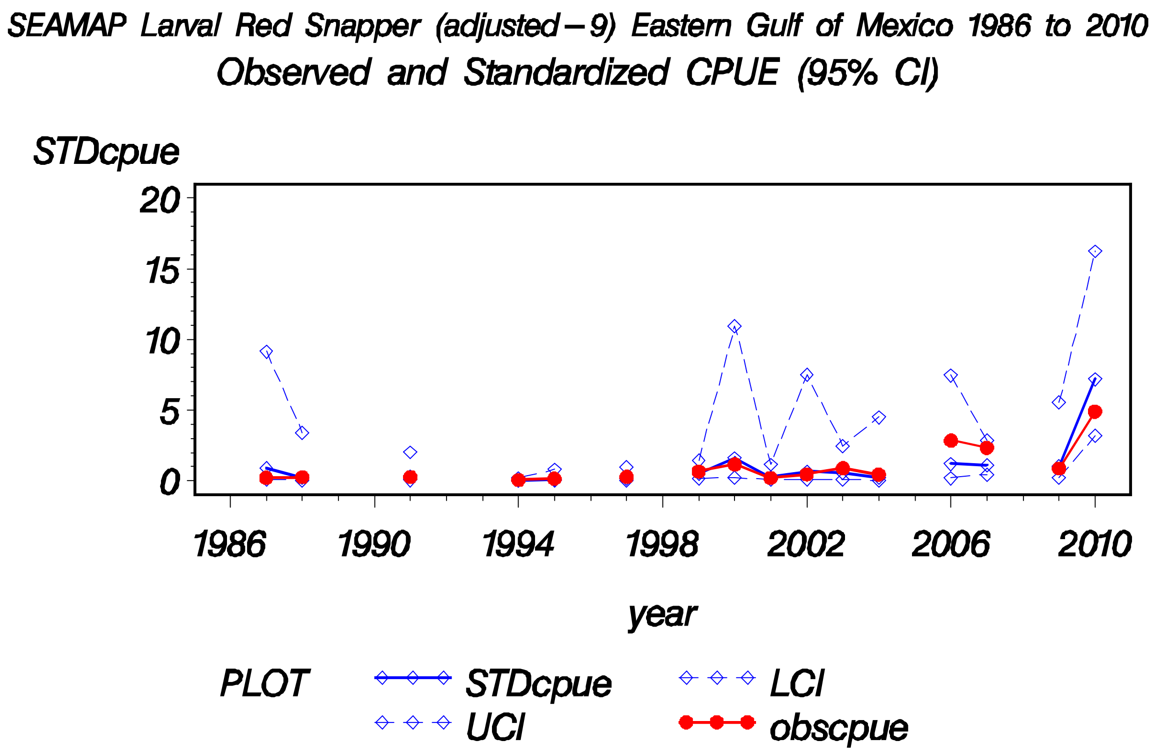
Addendum Figure 13. Diagnostic plots for binomial component of the larval red snapper adjusted to 10.5 days old SEAMAP Fall Plankton Survey (Eastern Gulf of Mexico) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by time of day and**C.** the Chi-Square residuals by subregion.



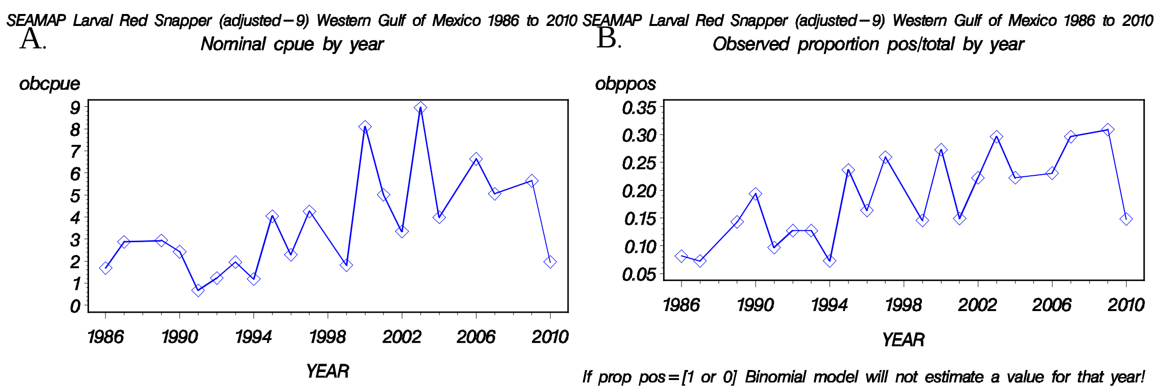
Addendum Figure 14. Diagnostic plots for lognormal component of the larval red snapper adjusted to 10.5 days old SEAMAP Fall Plankton Survey (Eastern Gulf of Mexico) model: **A.** the frequency distribution of log(CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).



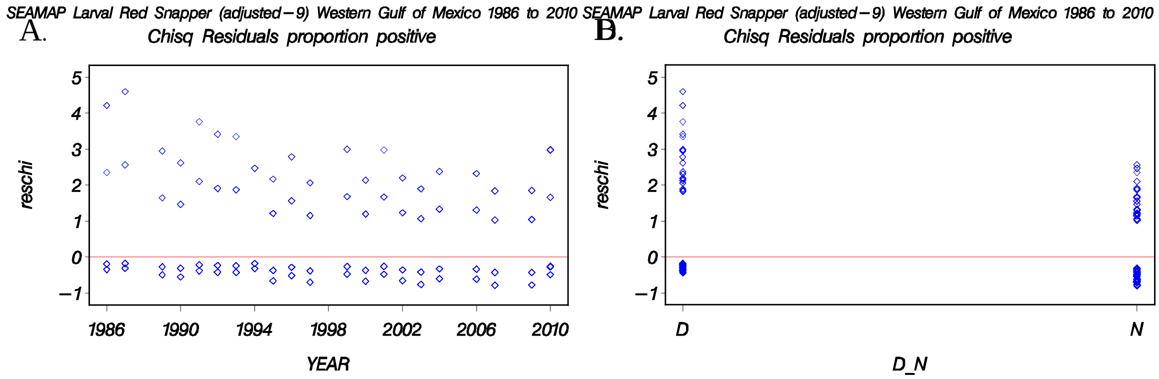
Addendum Figure 15. Diagnostic plots for lognormal component of the larvalred snapper adjusted to 10.5 days old SEAMAP Fall Plankton Survey (Eastern Gulf of Mexico) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by time of day and **C.** the Chi-Square residuals by subregion.



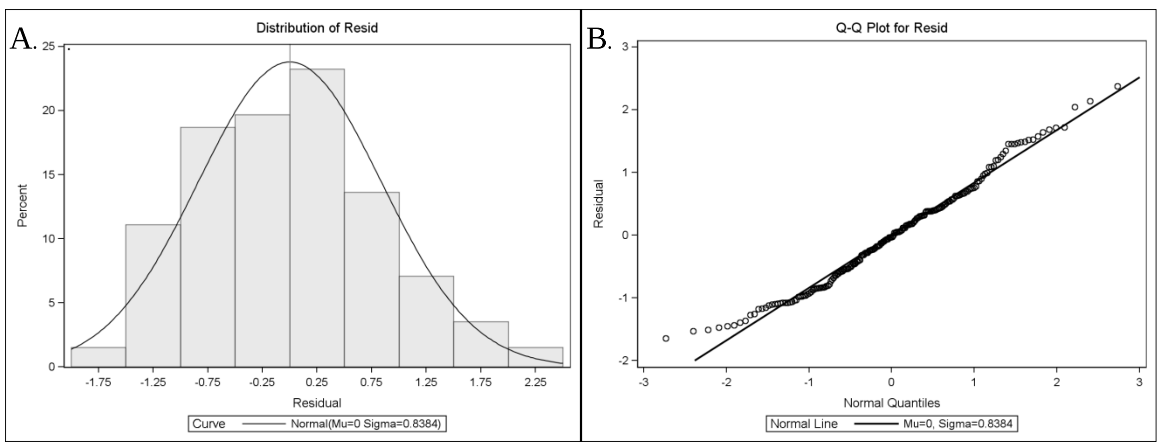
Addendum Figure 16. Annual index of abundance for larvalred snapper adjusted to 10.5 days old (Eastern Gulf of Mexico) from the SEAMAP Fall Plankton Survey from 1986 – 2010.



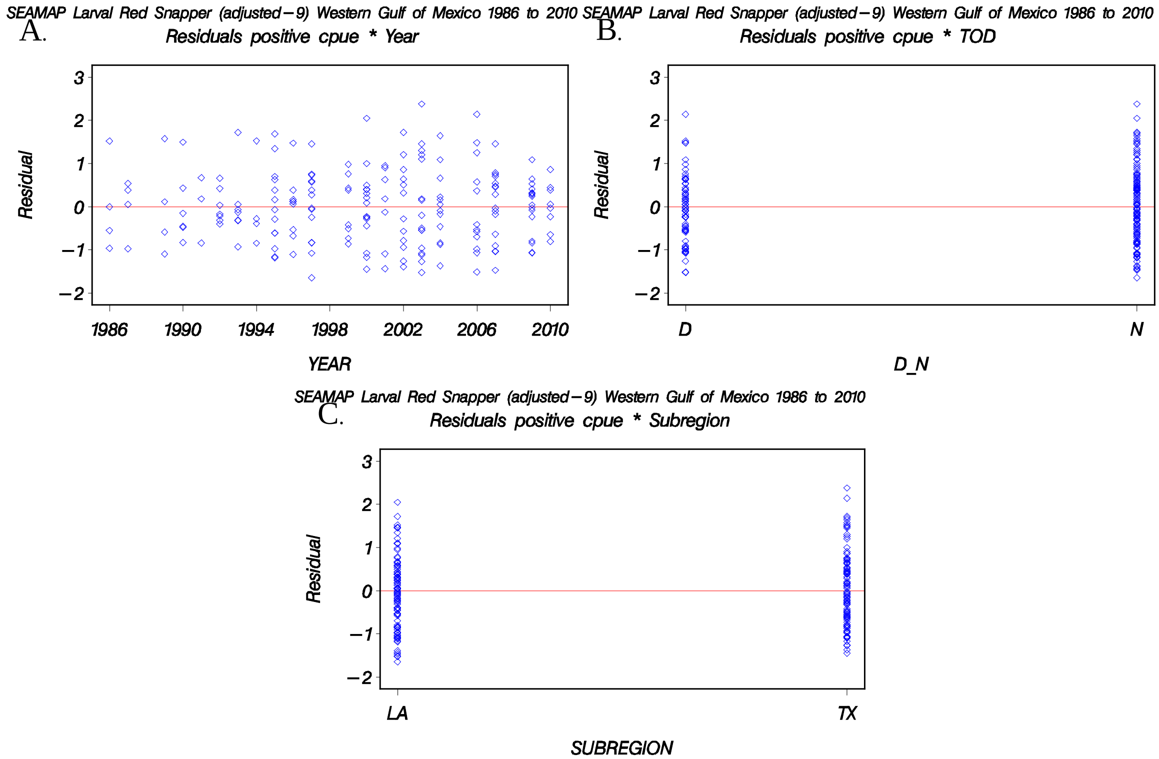
Addendum Figure 17. Annual trends for larvalred snapper adjusted to 10.5 days old captured during the SEAMAP Fall Plankton Survey (Western Gulf of Mexico) from 1986 to 2010 in **A.** nominal CPUE and **B.** proportion of positive stations.



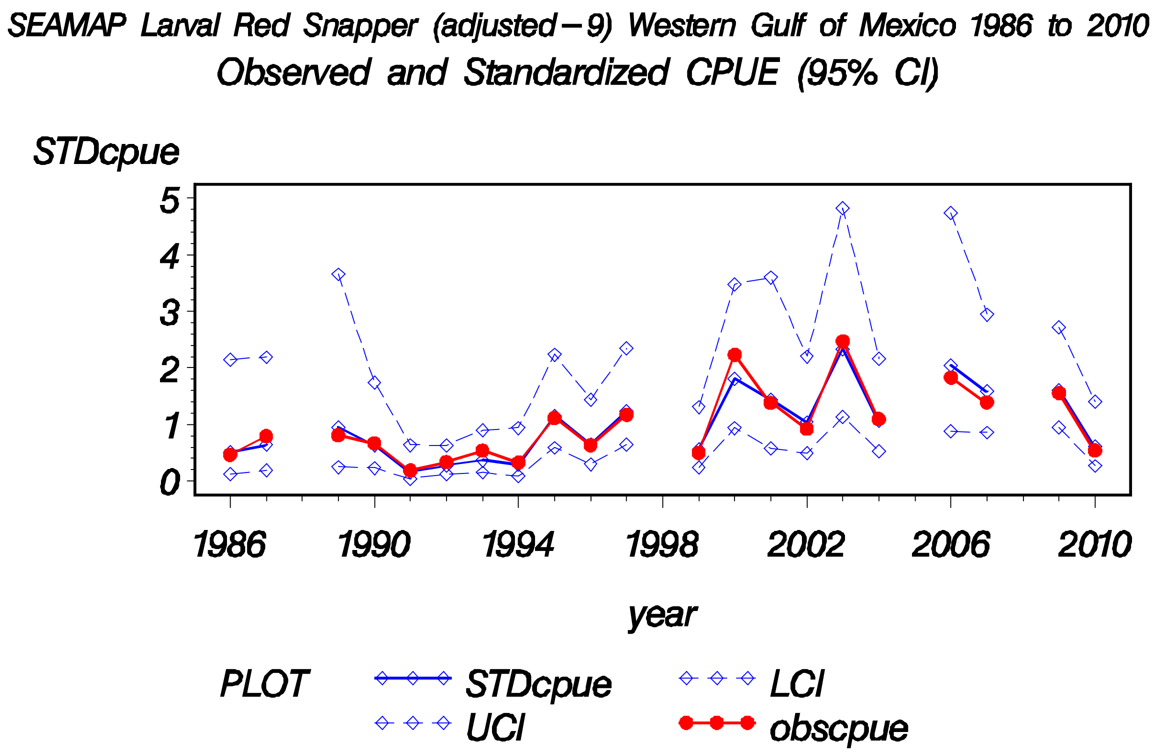
Addendum Figure 18. Diagnostic plots for binomial component of the larval red snapper adjusted to 10.5 days old SEAMAP Fall Plankton Survey (Western Gulf of Mexico) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by time of day and**C.** the Chi-Square residuals by subregion.



Addendum Figure 19. Diagnostic plots for lognormal component of the larval red snapper adjusted to 10.5 days old SEAMAP Fall Plankton Survey (Western Gulf of Mexico) model: **A.** the frequency distribution of log(CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).



Addendum Figure 20. Diagnostic plots for lognormal component of the larvalred snapper adjusted to 10.5 days old SEAMAP Fall Plankton Survey (Western Gulf of Mexico) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by time of day and **C.** the Chi-Square residuals by subregion.



Addendum Figure 21. Annual index of abundance for larvalred snapper adjusted to 10.5 days old (Western Gulf of Mexico) from the SEAMAP Fall Plankton Survey from 1986 – 2010.